

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
In Cooperation with the Texas Agricultural Experiment Station

SOIL SURVEY
OF
WILLACY COUNTY, TEXAS

BY

H. W. HAWKER, Texas Agricultural Experiment Station, in Charge
and C. S. SIMMONS, U. S. Department of Agriculture



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COUNTY SURVEYED

Willacy County is in the extreme southern tip of Texas and is only one county removed from the Rio Grande, which forms the boundary between the United States and Mexico. The Gulf of Mexico forms the eastern county boundary. The county occupies the northeastern part of the region generally referred to as the lower Rio Grande Valley or the delta of the Rio Grande. The county includes a part of Padre Island, a long narrow island which is separated from the mainland by the Laguna Madre. The island is from 5 to 8 miles distant from the mainland and together with the laguna separates the rest of the county from the Gulf of Mexico.

Raymondville, the county seat, is about 220 miles southeast of San Antonio and 120 and 300 miles southwest of Corpus Christi and Houston, respectively.

The land area of the county is 601 square miles, or 384,640 acres. The longest east-and-west dimension exclusive of the Laguna Madre and Padre Island, is about 35 miles, and the longest north-and-south dimension, which is in the eastern part, is 20 miles.

Physiographically the county is a level, undissected plain. From the western edge, where the average elevation is 50 feet above sea level,¹ the land slopes gradually eastward toward the Laguna Madre. At the shore of the Laguna Madre the elevation varies from 3 to 10 feet above sea level. For a distance of about 7 miles from the western county line the eastward slope is about 2 feet to the mile, and from that point to the Laguna Madre the slope averages about 1 foot to the mile.

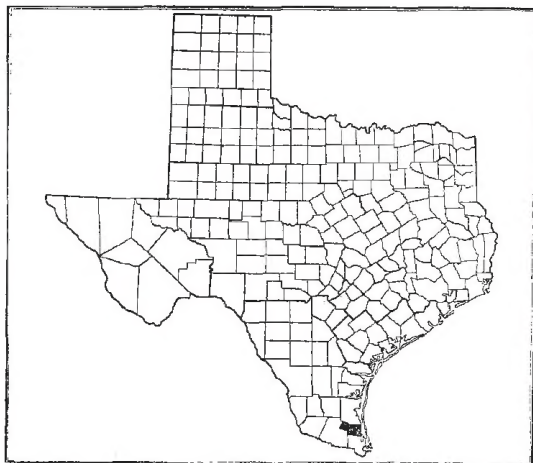


FIGURE 1.—Sketch map showing location of Willacy County, Tex.

¹ Elevations quoted in this report are mainly from the U. S. Geological Survey maps, and records from triangulation and traverse stations which are located in various parts of the county.

Four noticeable physiographic features exist in this plain. The first of these is La Sal Vieja, the old Spanish name for two salt lakes in the western part of the county, one of which occupies about 1 and the other 3 square miles. These lakes occupy shallow depressions averaging about 12 feet above sea level. They are fed to a slight extent by rains and the drainage from a very small adjacent area, but apparently the main water supply is salt and flows in a sandy stratum which occurs at the 12-foot level. Following continued evaporation of water during the hot summer months, these lakes become dry or nearly dry. Although these lakes may have been originally a part of the Gulf of Mexico, the depressions may owe their existence largely to the removal of soil material by the prevailing southeasterly winds.

Although drainage waters may be responsible to some extent for the numerous arms and bays extending inland from the Laguna Madre, the removal of soil material by the winds accounts in a measure for their present depth and configuration. These inlets constitute a second physiographic feature. The quantity of natural drainage received by them is comparatively small, and generally they contain water only during the wet seasons or when storms force the water of the Laguna Madre over the low bars at the mouths of the inlets back for some distance into the channels. The water of these inlets is almost entirely removed by evaporation. The fresh water they receive is made brackish by the salt content of the soil at the bottom of the channels. Following evaporation and drying out, the soil material deflocculates, becomes fluffy, and is easily carried away by the prevailing winds.

The third physiographic feature includes the dunes, the material of which has been removed from the old salt lakes and the bays and channels extending back from the Laguna Madre. In its present form this material comprises a series of mounds and ridges on the northwest side of the depressions and smooth, comparatively gentle slopes on the southeast side. Slight erosion has altered the natural form of the dunes, which are composed of fine material mainly of fine sand and clay. At present the dunes are stationary, receiving only small quantities of material on the surface during the dry seasons. Most of the soil material has lost its salt, as is evidenced by the vegetation. The largest of these dunes are northwest of La Sal Vieja. They occupy an area of about 3 square miles and have a maximum elevation of about 50 feet above the level of the adjacent country. Most of the dunes in the eastern part of the county lie from 10 to 20 feet above the surrounding territory and are chiefly elongated mounds from 300 to slightly more than 500 feet in width and from one-fourth mile to 2 miles in length.

The fourth and the chief feature of surface relief consists of the sand dunes in the northeastern part of the county, together with the adjacent depressions from which the material composing the dunes has been removed. Most of these sand dunes are still shifting, though some have been covered by a growth of grass and some mesquite or by a heavy growth of scrub live oak. The dunes extend in a northwest-southeast direction, that of the prevailing winds, range from one-fourth to more than 1 mile in width, and are several miles in length. Their elevation above the adjacent stationary plain ranges from 15 to 40 or more feet. The material from which they are

derived is that of the loose sandy belt which extends across the northern part of the county. This sandy material was perhaps originally blown from the Gulf of Mexico. Similar dunes and shifting loose sands occur on Padre Island, and the island may be said to be a large dune formed by sands washed out of the Gulf and subsequently reworked by the wind.

Numerous small depressions having distinct pothole characteristics occur in some parts of the county. They are either the result of wind erosion or were formed as sink holes following the leaching of the underlying lime carbonates. They vary from 50 feet in diameter to several acres in extent.

Although the greater part of the county is a part of the old Rio Grande flood plain, no definite channel of that river remains in Willacy County. Flood waters from the Rio Grande spread over a wide area, the general direction of the flow being eastward and northeastward from a point about 7 miles west of Lyford and mainly eastward beyond Raymondville. However, floods of sufficient magnitude to inundate parts of Willacy County are rare. The last one occurred in 1921, when the flood water covered the lower part of fields west of Sebastian, Lyford, and Raymondville to a depth varying from 6 to 12 inches. Recurrence of flood damage will be prevented, it is said, by the flood prevention and control work being conducted in Hidalgo County at the present time (1926). That part of Willacy County west of a point about 7 miles west of Raymondville and the sandy belt in the northern part are higher and are not affected by flood waters.

On account of the low average annual rainfall and the porosity of the soil, no definite drainage channels have developed in Willacy County.

As has been stated, the average elevation above sea level along the west county line is 50 feet. Elevations at other points are as follows: Raymondville, 31 feet; Lyford, 37 feet; Sebastian, 39 feet; Yturria, approximately 40 feet; El Sauz ranch, from 15 to 20 feet; and Santa Margarita School, 21 feet. The broad, flat coastal plain east of Nopal ranch is only a few feet above the level of the sea. The highest elevation in the county, 90 feet, is on the highland northwest of La Sal Vieja, and the lowest is along the Laguna Madre.

The conquest of Central America and Mexico by the Spanish had a wide influence on the country of which Willacy County is a part. Exploring parties are said to have left Tampico, Mexico, as early as 1526, traveling northward along the coast and adjacent interior (5).² These early explorers, on their way into the interior of Texas, undoubtedly passed through the territory including Willacy County, and the early trails were no doubt often traveled after 1722, when a mission was established at San Antonio de Bexar, the present San Antonio.

During the year 1767 a royal commission of the King of Spain drew up regulations for the taking up of land grants in the territory along the Rio Grande, and large areas adjacent to the river were immediately taken up by the early colonists. The territory of which Willacy County is a part was not granted until between 1790 and 1794. The first grant made was that of the San Juan de Carricitas tract, which included among other lands nine-tenths of Willacy

² Italic figures in parentheses refer to literature cited, p. 57.

County. The Mestenas grant, which included the remainder of the county, with the exception of about 6,000 acres, and also a large area in the present Hidalgo County, was made in 1794, and the remaining 6,000 acres in the northwestern part of the county were granted with the large San Salvador del Tulle tract. Following the death of the original grantees the lands were subdivided among their heirs, and the large holdings were thus broken up. The original titles were reaffirmed by the Mexican Government following its declaration of independence in 1821, by the Texas Government in 1836 though the territory south of the Nueces River was still claimed by the State of Tamaulipas, Mexico, and by the United States following the Mexican War in 1846 when Texas became a part of the United States. The title to all lands in the county is based on these early Spanish grants.

It is reported that a few Americans entered the territory prior to 1846, but the number increased following the Mexican War and Americans acquired titles to lands at about that time. The nucleus of the famous King ranch, a large part of which is in Willacy County, was acquired about 1850. Some of the larger Mexican ranch owners are descendants of the original grantees.

Trouble with the Indians was experienced in the general region, some outbreaks occurring as late as 1875. Some fighting during the Civil war occurred in the neighborhood of the Rio Grande. During 1915 and 1916 bandits crossed the river from Mexico, stole horses and cattle, pillaged, and murdered, and then returned to their base.

Within the last 10 years, especially since 1924, a number of large tracts of ranch land have been divided into holdings ranging from 40 to 200 acres. At the present time (1926) about half of the land in the county which is suitable for farming under dry-land conditions has been divided into small farms and sold, almost exclusively to residents of the northern, eastern, and southern parts of the United States. A cosmopolitan American population has resulted.

Following the Guadalupe Hidalgo treaty between the Mexican and American Governments in 1848, the territory now included in Willacy County became a part of Nueces County, Tex. Shortly afterwards it became a part of Cameron County. When Hidalgo County was formed in 1852 it included the western part of the present Willacy County, then part of Cameron County. The original Willacy County, which included the northern part of the present Willacy County and part of Kenedy County, was formed from parts of Hidalgo and Cameron Counties in 1911. The present Willacy County was formed from parts of the original Willacy County and parts of Hidalgo and Cameron Counties in 1921, and Raymondville became the county seat.

The early residents of the county were of Spanish and Mexican descent, and their principal occupation was ranching. The several ranch headquarters were the nucleuses of small settlements, the inhabitants of which were employed on the ranches. After the construction of the St. Louis, Brownsville & Mexico Railway in 1904, the towns of Raymondville, Lyford, and Sebastian were established. Prior to the construction of the railway, Brownsville, Alice, and later Falfurrias were the principal trading points. A stage line operated between Brownsville and Alice for several years prior to the Civil War, and following the cessation of hostilities operation was again taken up and the stage was the principal method of travel. The stage road

traversed the eastern part of Willacy County, crossing Arroyo Colorado at the site of the present ferry at Paso Real. El Sauz ranch was an overnight stop and way station along the stage line. Prior to the construction of the railway cattle were driven overland to points as far north as Kansas, but after the extension of railway lines to Fort Worth and later to Hebbbronville and Alice, these towns became the principal shipping points. One of the early interior trading points was located at the La Coma ranch, in eastern Hidalgo County, at which place a cotton gin was established in 1902. Small commissaries were located at the principal ranches.

The development of the country now included in Willacy County began when the St. Louis, Brownsville & Mexico Railway, now a part of the Missouri Pacific system, was built in 1904. This railroad was extended westward from Raymondville during 1926 and now furnishes transportation facilities to a large area of newly developed country.

No population statistics for Willacy County have been gathered since its formation in 1921, but in 1926 the number of inhabitants was estimated as 6,000, of which total probably 40 per cent was Mexican. Lyford and Raymondville were each credited with a population of about 400 in 1920, and Sebastian had 219 inhabitants. In 1924 Raymondville had a population of more than 1,100, 40 per cent of whom were Mexicans. The estimated population of Raymondville in 1926 is between 2,500 and 3,000. Perhaps 35 per cent of this number are Mexicans. In 1926 the population of Lyford was estimated as 500, that of Sebastian as 200, and that of Lasara as about 100.

The county as a whole is dependent on its agricultural resources and associated industries. Cotton gins are located in all the towns, and several are situated at points of vantage throughout the county. A compress and a bonded warehouse, which acts to some extent as a cooperative market for farm produce, are in Raymondville.

Except in the extreme eastern part of the county, which is mainly ranching country, good transportation facilities are furnished by the lines of the Missouri Pacific system. The main line from Brownsville crosses the county from south to north and the westward extension crosses the western part.

In the summer of 1926 all the highways of the county were of dirt construction. The sandy loam soils consist of coarse and fine material which makes good natural road material. Only the most important highways are dragged. Highways across areas of heavy soils or depressions generally become impassable during continued wet weather. Bonds have been voted for the construction of a hard-surfaced road paralleling the railroad from Sebastian to the north county line. The Old Mexican Trail branches off from the Old Spanish Trail at Red Gate, 20 miles west of Raymondville, passes through Raymondville, and turns southward through Lyford and Sebastian to Brownsville and Matamoros, Mexico. The main streets of Raymondville, a thoroughly modern town, are paved.

The educational facilities of the county as a whole are good. High schools are located at Raymondville, Lyford, and Sebastian. Telephone and rural mail service are available throughout the county. The country homes of Americans and some Mexicans are generally good, and a few of them are excellent.

CLIMATE

The climate of Willacy County is both semitropical and semihumid. The county lies almost entirely east of the ninety-eighth meridian, which passes through the extreme western part, and between the twenty-sixth and twenty-seventh parallels of latitude, less than 200 miles north of the Torrid Zone. The location and the average elevation of less than 50 feet above sea level have a tendency to produce semitropical temperatures. The climate is marked by a dry season and a wet season. Violent storms and torrential rains, common to tropical regions adjacent to the seas, sometimes occur.

Winter is the season of the lowest precipitation and fall of the highest. The heaviest rains generally occur during May, June, and September.

The influence of the wet and dry seasons on the staple crops of Willacy County is important. The months having low or moderate rainfall, February and March, are those in which planting takes place. These months are followed by a rainy period during the growing season of April, May, and June, and the harvest months of July and August have little rainfall. A comparatively high rainfall during the fall months prepares the soil for cultivation and also stores moisture in the ground for fall feed crops, special winter crops, and early spring crops.

Destructive hailstorms have occurred rarely. Occasionally during the winter rains occur in connection with cold winds, the rain freezing as it falls and covering the vegetation with ice. Small flurries of snow occur occasionally.

The average temperatures, as recorded at the Weather Bureau station at Raymondville, show a variation of less than 24° F. between the summer and winter means. The mean temperatures for the spring and fall are nearly the same. The difference between the highest and lowest temperatures recorded is 93°. The average latest killing frost is on February 21 and the latest frost recorded occurred on March 17. The average first killing frost is on December 20, and the earliest recorded was on November 16. The average frost-free season is 10 months. Some crops which are not affected by frost and light freezes are grown through the winter. Temperatures ranging from 104° to 109° F. occur during the period from April to September. The prevailing southeasterly breezes from the Gulf of Mexico eastward modify the high temperatures and make the moderate temperatures delightful. The nights are comfortable during the warmest months, except in cloudy weather or when the wind ceases.

The lowest temperatures experienced during the winter months accompany northers, a term applied to moderately high winds from the north and northeast. A fall in temperature ranging from 20° to 30° F. within a few hours after the norther strikes is not uncommon. In a few days the temperature returns to normal, and the prevailing southeasterly wind again occurs.

Occasionally a winter passes without the occurrence of a killing frost, and in some winters only one or two occur. The tender special crops and citrus trees may be damaged more or less by the more severe frosts and freezing weather (6).

Table 1 gives the normal monthly, seasonal, and annual temperature and precipitation at Raymondville.

TABLE 1.—Normal monthly, seasonal, and annual temperature and precipitation at Raymondville

[Elevation, 81 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1917)	Total amount for the wettest year (1922)
	^{° F.}	^{° F.}	^{° F.}	<i>Inches</i>	<i>Inches</i>	<i>Inches</i>
December.....	61.2	91	20	1.45	0.05	0.18
January.....	58.6	92	16	1.66	.24	1.34
February.....	62.3	97	22	.73	.72	1.37
Winter.....	60.7	97	16	3.84	1.01	2.89
March.....	67.5	99	21	1.00	.34	1.64
April.....	73.4	104	38	1.36	.05	.82
May.....	79.5	105	48	3.04	1.95	5.26
Spring.....	73.5	105	21	5.40	2.34	7.72
June.....	82.9	109	56	2.70	.27	7.19
July.....	84.7	107	63	2.44	3.48	1.19
August.....	85.4	107	65	1.38	.05	.69
Summer.....	84.3	109	56	6.52	3.80	9.07
September.....	80.8	105	49	3.99	1.52	11.13
October.....	74.4	100	36	3.41	.08	.32
November.....	66.9	98	29	1.55	.03	4.45
Fall.....	74.0	105	29	8.95	1.63	15.90
Year.....	73.2	100	16	24.71	8.78	35.58

AGRICULTURE

At the time the Spanish grants were made the land now included in Willacy County was regarded as unfit for any purpose other than cattle raising and large areas were granted to individuals. Some of the original grantees and their early successors attempted to raise cattle and horses, but under the tremendous handicap of constant raids by thieves and bandits, this industry did not assume large proportions prior to the Civil War. About 1875, after a large area had again been placed under the control of individual interests and the cattle industry had expanded, this area was fenced from near the Nueces River to the Arroyo Colorado in the eastern part of Willacy County. Following this, the industry was not so much harassed as a whole, but sporadic outbreaks of thievery and banditry continued until about 1916, after the Mexican invasion and the quelling of border raids. In the early days cultivated crops, consisting mainly of corn and garden produce, were planted only around the various ranch headquarters.

Between 1890 and 1900 some cotton was planted in this part of the State. Since no gins were available much of the crop was taken to points in the central and northern parts of the State for ginning and sale. Shortly after 1890 a gin was established near San Juan in Hidalgo County, but it operated for only a short time. Some of the

first cotton raised in this general vicinity was taken to a gin on the Mexican side of the Rio Grande, near Matamoros. About 1901 a gin was built on the La Coma ranch, about 8 miles beyond the western county line, and several large fields were planted to cotton in that vicinity. The coming of the railroad caused some of the adjacent ranch lands to be used for farming operations, and it is estimated that there were about 300 acres under the plow in 1906, two-thirds of which was planted to cotton. The first cotton gin in Willacy County was built in 1906 at Raymondville, and subsequently agriculture expanded more rapidly. During a lull in border troubles a large acreage of land along the railroad was sold to northern people, who cleared their lands and did some planting. Many farms, however, were deserted on the resumption of trouble during 1915 and 1916, many people abandoning all their livestock, growing crops, and household and farming equipment. They returned in 1917 and 1918 to make a new start.

Following the quelling of border raids some of the larger ranches of the county were divided into farms, and the land was sold to northern and eastern people. The taking up of farming lands in tracts varying from 40 to 120 or more acres has been particularly active since early in 1925, and it is estimated that the 413 farms reported in the county by the Bureau of the Census on January 1, 1925, had about doubled by the end of 1926.

In the early days the cattle industry was also hampered by the distance to markets. A few cattle were driven to Brazos de Santiago, a port on the Gulf of Mexico near Brownsville, and to other Mexican ports and were shipped by boat. In the year 1870 or thereabout large herds were collected and driven overland to railroad points in Kansas. These drives were shortened when the railroad reached Fort Worth, and still more when it reached Alice and Hebbronville. Although cattle raising was the chief industry until recently, within the last 10 years the value of farm crops has surpassed the income derived from cattle raising. The encroachment of mesquite, prickly pear, and other trees and shrubs on the grass-covered prairies has been instrumental in the decline of the cattle industry.

No general census of Willacy County has been taken since the formation of the present county. The only available figures covering the agriculture of this county are contained in the farm census of 1925.

The agricultural development of the county is progressing rapidly, and further development is assured. The number of farms on January 1, 1925, was 413, but estimates show that at this time (1926) it is 750 or 800. The 74,995 acres reported in farm lands in 1925 has increased until there are now about 90,000 acres in farms.

Three types of farming prevail in Willacy County: The raising of cattle and other livestock, the production of farm crops, and dairying. Among the special crops grown are onions, watermelons, potatoes, other vegetables, and citrus fruits.

The cattle industry was originally limited to the raising of native cattle. The climatic conditions, together with a fairly good grass growth, rendered this section of the country favorable for this industry. The cattle were used to stock the ranges in the northern part of the United States. The native stock has been largely replaced with grade cattle through the introduction of purebred bulls and cows. The first breeds of cattle used to improve the native herds

were the Shorthorn and Hereford, particularly the latter. It is estimated that more than 80 per cent of the cattle on ranches in Willacy County are grade Herefords. Of late years owners of some of the largest ranches have favored the Brahman breed and have imported a large number of purebred bulls and a few cows of this breed. As a result, many of the young animals on these ranches are grade Brahmans. The chief drawback to cattle raising is the dry climate which reduces the grass and water supply. The total number of beef cattle in Willacy County in 1925 was 3,098. This total has probably increased slightly in the last two years.

The total number of dairy cattle in the county on January 1, 1925, according to the census, was 1,850. Of this number 1,076 were dairy cows 2 or more years old. During the last few years, according to local reports, the number has decreased, owing mainly, it is said, to a shortage of feed during droughty years as well as to the inability of some dairymen to conduct their business economically. Most of the dairy cattle are high-grade stock and a few are purebred Jerseys. Raymondville and the small towns of the county are the only local markets for dairy products. One large and several smaller dairy herds are maintained near Raymondville. The large herd supplies that city with milk, and some cream is shipped to out-of-town dairies. The smaller herds produce a small quantity of butter, and a little cream is shipped. The supply of locally manufactured butter is insufficient to meet the local demand, and large quantities of this product are shipped into the county, sometimes from distant markets.

The raising of horses is only a minor industry. According to the 1925 farm census there were in Willacy County on January 1, 1925, 1,093 horses and 1,207 mules, an average of about 5 animals to the farm. A few flocks of short-haired Mexican goats are raised for their meat and hides. Only a few sheep are raised. It would seem that the large acreage of bush land and the semihumid climate would warrant sheep and goat raising on a large scale.

Very few farmers are interested in hog raising, as the larger markets are distant and the climate of Willacy County is not conducive to curing meat without proper cold-storage plants. Only 241 swine were reported in the county on January 1, 1925.

Most farmers keep a few chickens to provide themselves with eggs and meat. The poultry industry could be profitably extended to provide the local markets with eggs or broilers much of the time. Until recently no particular attention was given to the raising of purebred chickens.

When the ranch lands were subdivided into farming lands, it became necessary to clear away the growth of mesquite and other trees and the more or less thick growth of underbrush, consisting of various kinds of thorny shrubs and prickly pear. Most of the clearing has been done by Mexican labor at a price varying from \$15 to \$25 an acre. The larger trees are used for fuel and posts, and the underbrush is burned. The prickly pear growth is generally plowed under with tractor-drawn plows. The first lands cleared were chiefly along the main line of the railroad and along the highway east and west of Raymondville, but recently a large acreage has been cleared in the vicinity of Lasara and west of that place. The agricultural development of fairly large areas east of Lyford and Sebastian and

north, east, and west of Raymondville is now under way. Owing to the thicker growth of trees and heavier underbrush east of Lasara, the land in that locality is more difficult to clear. The land in the sand belt in the northern part of the county, the salty lands of the marine plain, and the salty alluvial soils will probably be utilized very largely as pasture land, on account of their unsuitability for the production of general farm crops.

In the early days the rancher raised only such crops as he needed to meet the requirements of his employees. These included corn, dry edible beans, and garden vegetables. Most of the soils are well supplied with plant food, and the element most necessary for crop production is a sufficient water supply. Although the average annual rainfall at Raymondville, measured over a long period of years, is 24.71 inches, the figures for the last 15 years indicate that in 10 of the 15 years the rainfall was above the average. In two years during that period more than 35 inches of rain fell, and in five years only was the rainfall less than 25 inches. Thus it would seem that successful crops should be obtained about two-thirds of the time. However, since successful crop production demands more moisture in the soil during the winter, spring, and early summer than in late summer and fall, a favorable distribution rather than a large quantity of rainfall is important. Good crops have been obtained in some years in which the annual rainfall was low but favorably distributed, whereas in years in which the total rainfall was high but unfavorably distributed crop returns were below the average.

The farm water supply has always been and still is insufficient for the most successful agricultural development of the county. In the region beginning about 2 miles north of Lyford, extending south beyond Sebastian, west into Hidalgo County, and eastward for a long distance is a shallow sweet-water belt. In much of this belt a stratum bearing fresh water seems to lie above the stratum bearing salt water, which occurs at a comparatively slight depth over the greater part of the county. In most places water from the last-mentioned stratum is sufficiently saline to be unpalatable for man or beast. It is necessary that wells be very carefully constructed in order to make use of the sweet and exclude the salty water. An abundant supply of sweet water has been obtained for more than 10 years from some of these wells, which range from 20 to 30 feet in depth. Where the sweet water is not available, artesian water must be obtained. In a small area south of Lasara, artesian water is reached between depths of 200 and 300 feet, but the strata bearing the artesian water lie mainly at a depth ranging from 800 to 1,500 feet. The expense of procuring water from this stratum is enormous, generally prohibitive for the individual landowner. In the development of some of the larger tracts of land artesian wells have been provided for each two sections, landowners having been deeded, with each 40 acres of land purchased, a one thirty-second interest in the well. The water from this central well is piped to the several homesteads. Most of the artesian water in the county is slightly saline, though some is extraordinarily pure. Although most of the artesian-well water is palatable, the salt content of many of the wells is sufficient to preclude the use of the water for irrigation purposes. Its use causes hardening and baking of the soil. If sufficient water could be obtained in the sweet-water belt to supplement the normal rainfall, it could well be utilized in the production of winter vegetables or citrus fruits.

The United States Reclamation Service report on the lower Rio Grande Valley includes a plan for the irrigation of most of the lands of Willacy County through the use of drainage waters from the irrigated sections in Hidalgo and Cameron Counties. Such a plan is probably feasible, but it may be a long time before it is put into execution. It is said that some of the irrigation districts in Hidalgo County plan to bring their drainage waters north into La Sal Vieja, making possible the use of part if not all of the water for irrigation purposes in Willacy County. It must be borne in mind, however, that the water-soluble salts or alkali content of the drainage water will determine its value for irrigation purposes. If irrigation of the soils of Willacy County should prove feasible through this or other means, the same vegetables and citrus fruits grown in the irrigated sections of Hidalgo and Cameron Counties will produce well on the soils of Willacy County.

At present, all crops of the county are grown under unirrigated or dry-farming conditions. Under this form of agriculture it is necessary, especially in years in which the rainfall is near or below the average, to so handle the soils of the county as to create a moisture reservoir for the reception of winter, spring, and early summer rains; to keep down the weed growth; and to provide a soil mulch by cultivation. The greater natural moisture-holding capacity of the deeper, lighter-textured soils renders them more favorable for successful crop production under existent climatic conditions.

Although the run-off of rainfall is ordinarily very low in Willacy County, the high evaporation during the summer must be considered when farming operations are undertaken.

Corn was the chief crop of the early ranchers. The 1910 census figures for Cameron County, of which the greater part of the present Willacy County was a part and in which similar soils occur, show an average yield of 15 bushels of corn to the acre for the previous season. The agricultural census for 1925 reports that in Willacy County in 1924 there were 794 acres of corn grown for grain, yielding 18,286 bushels, an average of nearly 24 bushels to the acre. During the year 1926, when the moisture distribution was exceptionally favorable for corn production, it is estimated that 3,500 acres were planted to corn and that yields ranged from 30 to 50 bushels to the acre. The principal varieties grown in Willacy County are Surcropper, Tuxpan, and Mexican June, and there is a small acreage of Bloody Butcher. Tuxpan is said to give the best yields under optimum moisture conditions, but Surcropper, though making a lower average yield, is favored because a crop is assured even in a droughty season. Surcropper is considered the best variety for roasting ears and Mexican June is second. The sweet corns are so subject to insect damage that they are rarely grown for roasting ears.

At present cotton is the principal crop and occupies the largest acreage. In 1906 approximately 200 acres were planted to cotton in the region now comprising Willacy County, and the average yield was about one-fourth bale to the acre. In 1924 the 20,388 acres planted to cotton produced 5,905 bales, or approximately three-tenths bale to the acre. The 1926 production was approximately 20,500 bales, and the average yield in this favorable season was nearly one-half bale to the acre. Yields ranging from three-fourths to 1 bale were reported in that year. The varieties of cotton commonly

grown are Mebane, Kasch, Delfos, Acala, Rowden, and some Half-and-Half and Bennett's Lone Star. The chief foes to successful cotton production are Texas root rot (a fungous disease), the flea hopper, and the boll weevil. The root-rot fungus (10) was more prevalent during the wet season of 1926 than previously, but during the last few years very little trouble has been experienced with the flea hopper or the boll weevil. The leaf worm appeared during the latter part of 1926, but as the foliage was so heavy that year the loss of leaves was beneficial in that it allowed the lower bolls to open. Sulphur is used to combat the flea hopper (8, 9) and calcium arsenate for controlling the boll weevil (2, 4).

Sorghums, both for grain and forage, constitute the remaining important staple farm crops in Willacy County. Red Top or Sumac is the principal variety grown and is used chiefly as a feed crop. Darso also does well, as does White African, a variety preferred by some local farmers. Schrock and white milo were seen in a few small fields. Sorghum used for sirup occupies a comparatively small acreage. The quality of sirup obtained is affected by the saline content in most of the soils of the county.

Many farmers grow a small acreage of Sudan grass, some of which is cut for green feed and the remainder for hay. Two cuttings each year are obtained, except in unusually dry seasons or when the crop is affected by rust. The sorghums and Sudan grass produce from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons to the acre at each cutting. The yield of seed varies greatly with the season, but reports show that as high as 50 bushels to the acre of darso and white milo have been obtained. The average probably ranges from 15 to 25 bushels to the acre.

Some fields of Rhodes grass were seen during the survey. In years of well-distributed rainfall two and sometimes three cuttings are made, but ordinarily only one cutting and some pasturage are obtained. The average acre yield is about 1 ton at each cutting. Where a fairly clean growth of Colorado grass or crabgrass comes up following the removal of onions or watermelons or an early crop of cotton, it is sometimes cut for hay, producing yields varying from one-half to three-fourths ton to the acre under good moisture conditions. Hay crops were grown on 176 acres in 1924.

Onions constitute the chief special crop of Willacy County. The general practice is to sow onions and allow them to mature without resetting. Therefore this crop matures from 10 days to 2 weeks earlier in normal seasons than the same crop in most of the other Texas onion-producing sections. Onion production on a commercial scale was begun about 1918 in this county, and the success met by the growers has caused the acreage to increase until during the season of 1925-26 between 2,500 and 3,000 acres, yielding 225,000 crates, were raised. Two hundred and five carloads of onions were shipped out of Willacy County during this season. Bermuda and Crystal Wax varieties are grown, but the Bermuda leads in acreage. Larger average yields of the Bermuda variety are obtained, but the Crystal Wax generally brings a slightly higher market price. Frosts are rarely sufficiently severe to damage the onion crop, and in the past very little damage has been suffered from onion thrips. With too much rain some rotting occurs in the buds, and during the growing season there is a tendency to produce splits and doubles instead of the round, well-formed onion demanded for the best markets.

Watermelons rank second among the special crops grown. On account of their early maturity, they have recently become important in the agriculture of Willacy County. Some small patches are scattered over the county, but during 1926 the largest acreage planted was on the sandy soils in the vicinity of Yturria. Tom Watson is the chief shipping variety. In 1926, 97 carloads were produced from about 500 acres, in addition to a large tonnage distributed by automobile trucks throughout this section of the State. Some growers fertilize with 100 pounds of mixtures analyzing 2-8-2³ or 4-8-4. The use of fertilizer is said to insure smoother, more uniform melons and the absence of white hearts in the matured melon.

A small acreage of sweet potatoes, chiefly Nancy Hall and Porto Rico, is grown on the lighter soils. The Porto Rico appears to do better and to be preferred. Yields as high as 500 bushels to the acre have been obtained, but the average yield is much lower.

A fair-sized acreage of tomatoes will be planted in the fall of 1926. June Pink and Livingston Globe are the common and most favored varieties. Yields vary from 150 to 300 crates to the acre or slightly more in exceptional seasons. The total acreage is comparatively small.

Spring and fall crops of green snap beans also are a part of the county's farming program, and with fair moisture conditions good yields are obtained. Giant Stringless and Burpee's Stringless Green Pod are the favorite varieties. From 50 to 150 hampers to the acre of marketable beans are obtained.

Some farmers are planting cabbage and English peas as fall crops, but their success will depend on moisture conditions. A movement has been started by some farmers to plant a sufficient acreage of various vegetables to allow shipping a carload of mixed vegetables by individual growers, thus avoiding to some extent a glutted market.

Potatoes for the early spring markets have been successfully grown on a small acreage. The red Triumph varieties are the most common. Yields range from 60 to 75 bushels to the acre without fertilization, though yields as high as 160 bushels to the acre have been reported.

A small acreage of broomcorn of the Standard Evergreen variety was grown during the season of 1926. The yield obtained was reported as one-third ton to the acre for the first cutting. This was produced under the best moisture conditions, and the quality was said to be good.

Although the average annual rainfall of Willacy County is considered insufficient for the best culture of citrus trees (7, 3), a number of groves of good-sized orange and grapefruit trees, apparently of vigorous and uniform growth, are in the county. The total acreage of citrus trees is between 100 and 125 acres, but only about half of these are in bearing. Half the acreage is located in the city limits of Raymondville. A few bearing commercial orchards are at Lyford, and one is west of Sebastian. A number of small orchards have recently been set out. Of the 8,000 or 9,000 citrus fruit trees, 60 per cent are grapefruit, 30 per cent orange, and 10 per cent lemon. The chief grapefruit varieties are Duncan and Marsh, but some Walters and Pernambuco were also seen. The Marsh is preferred on account of the absence of seed, but the Duncan matures earlier and reaches the early market. Parson Brown, Pineapple, Valencia,

³ Percentages, respectively, of nitrogen, phosphoric acid, and potash.

and Washington Navel are the most common varieties of oranges, with Homosassa, Temple, Ruby, St. Michael, and Mediterranean Sweet represented in small numbers. Yields vary with seasons. The larger orange trees yield an average of 3 boxes to the tree or about 250 to the acre. Yields of grapefruit average between 2 and 3 boxes to the tree or from 150 to 250 to the acre. The quality of the citrus fruits, especially of oranges, is very good. Fruit produced in the nonirrigated section has taken prizes over fruit grown under irrigation.

Although the ordinary freezes cause little damage, in some seasons, notably during 1917 when most trees were frozen down to the protecting banks around their bases, and during the latter part of 1925, when ice and sleet ruined the fruit and caused considerable damage by breaking the branches, the trees have been greatly damaged. The trees in Willacy County are given no protection by heaters, as are trees in many groves in Hidalgo and Cameron Counties. In connection with citrus-fruit growing, there is a small nursery industry.

An important industry in Willacy County is the growing of onion, pepper, tomato, and cabbage plants for shipment to large vegetable-growing sections and to northern points where climatic conditions are such as to prevent the growth outdoors of early plants. Onion plants are procured from fields which require thinning of the seeded plants, as well as from fields sown for shipping purposes. The standard varieties of each kind of plant are grown. During the 1926 spring season more than 100,000,000 plants were shipped from Raymondville, 200 acres in that vicinity being used in the production of these plants. Some strawberries, blackberries, and dewberries have been grown for home use.

A great change has taken place in the utilization of the lands of the county during the last 20 years. The cultivated area has increased from 300 acres in 1906 to approximately 90,000 acres in 1926. During the fall and winter of 1926 a large acreage was cleared and planted to farm crops. Prior to 1904 nearly all the land now utilized for farming purposes was in cattle ranches.

The soils of the marine plain, the salty soils of the alluvial plains, and many of the soils in the sand belt, which together occupy about half of the county, will probably never be utilized in the production of farm crops. A large part of the remainder of the county is suitable for growing crops adapted to the region. Between 40 and 50 per cent of this half is at present farmed or has been divided and sold for small farms but is as yet uncleared.

The production of farm crops in Willacy County under dry-farming conditions is aided largely by the natural moisture-holding capacity of most of the soils. The more successful farmers plow the soils in fall to a considerable depth in order to create a reservoir for the winter and early spring rains. Frequent cultivations are made to retard the weed growth and provide a mulch for the conservation of soil moisture. Good rains in winter and early spring and at intervals during the early growing season are essential for the best yields of early crops, and rains during September are essential for the growing of fall crops. However, the early spring planting of crops is the general rule.

The adaptation of soils to certain crops has not been studied exhaustively in Willacy County, owing to the fact that agriculture is in its infancy. The sandy soils of the Nueces series are best adapted to the production of watermelons and sweet potatoes, and Willacy fine sandy loam and Victoria fine sandy loam are considered best for citrus production. The staple crops and onions have proved successful on most of the soils of the county, though many growers prefer the heavier soils for onion and potato production.

Methods of handling the various soils for different crops vary greatly with individual growers and to some extent with the character of the soil. The importance of deep plowing, frequent cultivation, and plowing under crop residues, weeds, and green manures is becoming more generally recognized.

Most of the farm machinery is good and of late design. Tractors are used on many farms, and the level surface of the soils and absence of drainage ways, rocks, or other interference are favorable for their use. The investment for machinery is generally high for the acreage involved.

The farmers are beginning to recognize the necessity for crop rotations, especially for growing such crops following cotton as are resistant to cotton root rot. However, many fields are planted to cotton year after year, as it is the principal cash crop of this section. The rotation most in use is cotton, 2 years, followed by sorghum 1 year, corn 1 year, and then cotton again. The climatic conditions allow the planting of cotton, fall corn, and sorghum, following the early onion crop.

Only a small quantity of commercial fertilizer is used in the county, but the quality of the special crops on which it has been applied shows that its use is profitable. The quantity applied will no doubt be increased. The use of standard formulas, analyzing 2-8-2 or 4-8-4, has proved profitable.

With the exception of cotton pickers, farm labor in Willacy County is almost all Mexican. During the cotton-picking season large numbers of negroes are brought into the county. Ordinarily the labor problem is rather easily solved, owing both to the high percentage of Mexican inhabitants and to the proximity of the county to Mexico. For general farm labor \$1 or \$1.50 a day is paid, and a few farmers provide a small house for the laborer's family. Cotton pickers are paid from 75 cents to \$1.25 a hundred pounds. The hoeing and grading of onions are paid for either at day rates or by the acre.

The average acreage to the farm in Willacy County is constantly decreasing, owing to the breaking up of ranches into small farms. The 1920 census covering Willacy County as it then existed showed a total of 58 farms, with an average acreage of 6,654 acres to the farm, of which 0.5 per cent, or 35 acres to the farm, was improved. The report of the Department of Commerce dated December 1, 1925, shows 413 farms, including 74,995 acres of the 384,640 acres in the county, or an average of about 180 acres to the farm. One-third of the improved acreage, or 60 acres to the farm, was crop land. Most of the individual holdings of farm lands range between 40 and 120 acres. The average crop-land area is constantly increasing as new lands are brought under cultivation. The ranches in the county range in size from a few hundred acres to 200,000 or more acres.

About 40 per cent of the farms were operated by owners in 1924. One farm was operated by a manager, and 60 per cent were operated by tenants, chiefly Mexicans. The percentage of tenancy is increasing.

The value of farm lands in Willacy County on January 1, 1925, was \$3,528,032, or slightly less than \$50 an acre. Buildings were valued at \$255,158, or approximately \$600 a farm. The price of farm lands has advanced considerably since that time, uncleared lands commanding from \$60 to \$100 an acre and cleared lands from \$75 to \$200 an acre, depending on location, improvements, and other features. Citrus-fruit orchards are held at much higher prices.

Most of the tenant farms in the county are leased on a share basis, the prevailing contract being that allowed by the Texas law; that is, one-third of all crops except cotton and one-fourth of that crop, where the owner furnishes the land alone. Where the owner furnishes the land, horses, and seed, he receives one-half the crop as rental. Very little land is rented for cash. Where special crops such as onions are grown, contracts vary. Many landowners furnish the land, prepare it for the onion crop, and supply the seed, receiving one-half the crop as rental.

SOILS

Willacy County lies on a smooth plain sloping very gently north-eastward. There are no stream channels within the boundaries of the county, and the run-off escapes slowly through a broad but very faint depression running from the county line southeast of Lasara northward and eastward by Raymondville. On account of the comparative sandiness of the soils most of the rain water is absorbed.

The northeastward slope of the surface is part of a slope beginning on the bluffs of the modern very shallow valley of the Rio Grande and forming the southern boundaries of Cameron and Hidalgo Counties, which lie south and southwest of Willacy County. The area covered by these three counties includes the greater part of that portion of the delta of the Rio Grande occurring north of the existing channel. The southern part of this delta is in Mexico. The location of its northern boundary was not determined during the surveying of these counties. The part of this delta in Willacy County is high enough so that it is rarely traversed by any water from the river. When the river is in very high flood stage, however, overflow water enters the county as a broad, shallow, slow stream without channel or stream bed, in the vicinity of the angle in the county line southeast of Lasara.

It is apparent that the extreme west end of the county is underlain by material older than that east of it and possibly older than the delta deposits. This material is not so heavy in texture as that covering an important part of the eastern half of the county. The soils have not attained so advanced a stage of weathering as those of Hidalgo County. In a strip along the northern boundary there is a covering of sand, which seems to have been blown southward from country to the north. It is possible that this sand covers a strip of soils older than those farther south. It is probable that Willacy County covers the northern part of the Rio Grande delta and that west of the county the north boundary of the delta runs southwestward, reaching the Rio Grande about 10 miles west of Mission. It is possible, though no rise of level makes it certain, that the Willacy soils occupying the west end of the county and a strip extending eastward immediately

south of the belt of sandy Nueces soils in the northern part of the county lie beyond the delta. The delta seems to have been built on a flat plain, and no marked change in elevation or relief shows its boundary.

The sand belt extending across the northern part of the county has been classed by geologists as recent material and ascribed as being due to sandy material washed and blown out of the Gulf of Mexico or the Laguna Madre (11). This material is underlain, at a depth varying from 2 to 6 feet below the surface in the smoother areas, by a heavy subsoil the upper surface of which is apparently level. The smoother areas have none of the aspects of a strictly wind-blown soil, such as alternating valleys and dunes, but mounds formed about trees and a few small ridges with axes in the direction of the prevailing winds give evidence of some wind action. Areas of moving dunes are also in this belt, mainly in the northeastern part of the county. Taking into consideration the possible eluviation of the finer soil material from the sandy material and its accumulation in a clay layer occurring at varying depths below the surface, and also the high percentage of flat areas in which there is very little, if any, sign of wind action, it is not improbable that the soil material in the western part of the county, at least, may be fluvial in origin.

This sandy belt occupies from 10 to 15 per cent of the area of the county. Its surface varies from nearly flat or level to hilly and dunelike, the dunes lying from 25 to 40 feet above the general level of the area. With the exception of the dune areas and several square miles of grass-covered or semiprairie land, the greater part of the sand belt is covered with a small brush growth, consisting principally of mesquite.

The area of wind-derived or wind-influenced soils includes Padre Island. This island has the typical dune relief. The material is similar to that of the sand belt and is still being moved by the winds.

East of a line connecting Tenerias, Carricitas, El Sauz, Los Mulatos, Nopal, and Las Guatesona ranches, the soils contain, below the upper foot or two, a rather high percentage of salts. This area includes the Lomalto and the salty phases of the Victoria and Nueces soils. These soils support, in addition to some of the typical tree, shrub, and grass growths found elsewhere, a moderate or heavy growth of sacahuista grass, and some other salt-loving plants, chief of which are sea orange (*Barrichita frutescens*) and white grass (*Homalocenchrus virginicus*). This area is a comparatively level plain, with very slight slope to the east.

Adjacent to the Laguna Madre and extending inland for distances varying from one-fourth to more than 8 miles, is a flat area of comparatively heavy soils, mostly prairie. The principal vegetation is sacahuista grass and other salt-loving plants, such as sea orange and seaside heliotrope. The inland extensions are chiefly in the form of bays and lagoons and may be either long narrow areas or areas of considerable size. The soil material included in this area consists largely of sedimentary material deposited by fresh water in shallow salt water and then reworked by marine forces. In this process a large amount of sodium chloride and other salts has been incorporated with the soil material. This salt content is sufficient to pre-

vent the growth of the trees, shrubs, and grasses common on the fresh-water soil material.

As a whole this marine plain is nearly flat, with an imperceptible slope to the east. Its elevation above sea level is so slight that part of it may be covered by salt water from Laguna Madre when a high wind forces the waters of the laguna inland over the low coastal beach bar along the shore. This water is also forced up the numerous comparatively narrow old stream channels which extend inland through this marine material and also through the area of salty soils west of it. Since little of these waters finds its way back to the sea, moisture is removed chiefly through evaporation and the salt present is deposited in the bottom of the depressions. Both the marine plain and the area of salty soils west of it are underlain at a slight depth by a sheet of salt water, which during rainy seasons rises and occupies small lake basins. Some of these small lakes were probably at one time part of old river channels up which salt water has been forced by storms or tides.

The high salt content of the soil in these basins and old channels is responsible for a series of mounds and elongated ridges lying from 5 to 15 feet or slightly more above the level of the surrounding country. These mounds and ridges occur on the leeward side of the depressions or basins and are the result of a combination of chemical and aeolian agencies. On drying, the salty soil of the basins becomes fluffy and loose, owing to the action of the salt. The soil in this condition is readily taken up by the prevailing winds and is deposited on the northwestern side of the depressions. The ridges have the typical dune contours, with a steeper slope on the leeward side of the dunes than on the windward side. Most of the mounds and ridges are symmetrical, though there are many incipient or immature dunes and some which have been affected by erosion. The most outstanding example of this process is northwest of La Sal Vieja, where the mounds are 35 or more feet above the surrounding territory, the material composing them having been blown out of the basins of the old salt lakes after the complete evaporation of the water. The area of soils formed through these combined agencies is less than 1 per cent of the total area of the county. These soil areas are mainly covered by the growth of grasses, shrubs, and trees common to the county, the gradual deposition of the material forming the mounds having allowed the salts which they originally contained to leach out. Some of the more recently deposited materials are still high in salt content and the vegetation is restricted to the somewhat salt-resistant plants. The clay dunes are higher in salt content than those composed mainly of fine sand.

Besides the classification of the soils of Willacy County on the basis of the agencies involved in the deposition of the soil material, they may be classified on the basis of their vegetation, the degree of leaching or stage of lime accumulation they have undergone since deposition, their alkali content, and their soil profile.

On the basis of vegetative growth the soils of the county may be classed as timbered and prairie. The typical timber growth of the county consists of mesquite, ebony, brazil, huisache, retama, and a variety of small shrubs, chiefly legumes. This growth, or a slight variation thereof, occurs on all the soils of the county except on a small area in the sand belt in the northeastern part, where live oak

is the only tree growth. Prairie areas include all the soils of the marine plain and part of the sand belt in the eastern part of the county.

On the basis of the stage of leaching of the soil carbonates and their accumulation in a definite layer in the soil, four classifications may be made: Soils in which the material has been leached of all soil carbonates within a depth ranging from 4 to 6 feet; soils which have been completely leached of free carbonates to a depth of 18 or more inches, and the soil carbonates accumulated in a definite layer beginning at an average depth of about 30 inches; soils which are calcareous from the surface downward, yet have a definite layer of lime accumulation or layer in which a maximum effervescence with hydrochloric acid is noted; and soils which appear to be uniformly calcareous from the surface downward. The soils of the first classification includes members of the Nueces series and dune sand of the sand belt; those of the second classification include the soils of the Willacy, Laredo, Point Isabel, Victoria, and Raymondville series; and the calcareous soils include the Lomalto soils of the marine plain.

Soils having similar profiles, a common origin, and like position with regard to overflow are grouped into series. Profile variations may be in color, structure of the surface soil and subsoil, lime content, or content of water-soluble salts. Each series may include several soil types, differentiated on the basis of the texture of the surface soil layer.

The Nueces soils have grayish-brown or brownish-gray surface soils underlain, at a depth varying from 6 to 15 inches, by light grayish-brown, grayish-yellow, or light-yellow material which may continue to a depth of 10 or more feet or which may be underlain below a depth of 2 feet by heavy bluish-gray clay, mottled with yellow and, in some places, with red. These soils are thoroughly leached of lime and show no evidence of a definite layer of lime accumulation above a depth of 4 feet. Nueces fine sand, with shallow, shallow salty, and prairie phases, is mapped.

The Willacy soils have dark grayish-brown or dark-brown surface soils, which vary in thickness from 12 to 20 inches. The subsoil consists of brown, friable, or semifriable material, which at a depth ranging from 24 to 30 inches becomes slightly lighter in color and at a depth from 30 to 36 inches becomes yellowish brown or pinkish buff. This material continues to a great depth. The subsoil is highly calcareous, and effervescence with lime may occur below the 18-inch depth but it rarely occurs above the 30-inch depth. Willacy fine sandy loam, with light-colored, salty, flat, and eroded phases, is mapped.

The Point Isabel series includes soils with grayish-brown or brownish-gray surface soils, overlying ash-gray or dark ash-gray friable fine sandy loam or clay subsoils at a depth varying from about 10 to 15 inches. This material grades into gray, cream-colored, or light grayish-brown material at about the 30-inch depth. The soil is calcareous throughout, but there is an apparent accumulation of lime in the cream-colored or light grayish-brown layer at and below the 30-inch depth. Point Isabel fine sandy loam, with a high phase, and Point Isabel clay are mapped.

Soils of the Victoria series have dark-brown or black surface soils grading, at a depth of 12 inches, into dark-brown or medium dark-brown friable subsoils, which pass through brown into yellowish-brown, buff-brown, or pinkish-buff friable, highly calcareous material at a depth ranging from 24 to 30 inches. Most of these soils, especially the heavier ones, are calcareous throughout. The fine sandy loam, with a salty phase, fine sandy clay loam, with a light-colored phase, the clay loam, with a light-colored phase and a salty phase, and the clay members of the Victoria series are mapped.

Soils of the Raymondville series have surface soils of grayish-brown, dark grayish-brown, or dark ash-gray shade, underlain at a depth ranging from 10 to 15 inches by ash-gray or light ash-gray clay which extends to a depth greater than 40 inches with little change. Below a depth of 30 inches the subsoil may become yellowish or slightly pinkish and may contain a few soft whitish lime accretions. Shells are usually numerous on the surface and throughout the surface soil and the upper part of the subsoil. These soils are calcareous throughout. The fine sandy clay loam, with a salty phase, the clay loam, with a salty phase, and the clay, with a salty phase, members of the Raymondville series are mapped.

Soils of the Laredo series are yellowish-brown or light-brown soils. They are calcareous from the surface downward. Laredo silt loam is mapped.

The soils of the marine plain are grouped in the Lomalto series. The surface soils are gray or brownish gray and are underlain by gray, yellowish-gray, and, in a few places, cream-colored clay at a depth ranging from about 10 to 20 inches. At a depth of about 30 inches pinkish material containing small lime concretions is present in some places. These soils are calcareous throughout. Lomalto fine sandy loam, Lomalto clay loam, Lomalto clay, and Lomalto and Nueces soils, undifferentiated, are mapped.

Soils of the Tiocano series have dark-brown, black, or dark ash-gray surface soils, overlying dark-gray or black heavy subsoils. Most of these soils are calcareous. Tiocano clay is mapped.

Excessive past and present wind action affecting material similar to that included in the Nueces soils has brought about the formation of the material classed as dune sand. Such areas are of dune relief, are devoid of vegetation, and are still shifting with even ordinary winds. The material has been thoroughly leached of soil carbonates, and there was no evidence of a definite layer of lime accumulation to a depth of 4 feet.

The classification coastal beach includes a strip of brownish sandy material between the Laguna Madre and higher lying lands. Coastal beach may be interstratified with gray or dark-gray clay, which may be calcareous. Many shell fragments are present in the upper part of the soil.

A characteristic of the fine sandy loam soils of the alluvial plain is the high percentage of silt and clay material present in the surface soil. When wet, this material causes the soil to be more sticky than usual. On drying, the fine soil grains adhere to the brown or grayish-brown fine sand grains, giving them a coarser feel and a darker color. However, dashing rains wash these dark-colored fine soil particles away, exposing the fine sand grains in their natural color at the

surface. This causes the surface of fields to appear lighter in color than typical.

The heavy soils also have this peculiar characteristic. Owing to their calcareousness they have a tendency to slake into small clods following continued dry weather. There is also a tendency for the clay particles to stick together and form grains the size of fine or medium sand. These become very hard, and it is almost impossible to crush them with the fingers. Clay soils under these conditions feel like fine sandy loam soils, and unless closely examined their heavy texture is not discerned.

In the following pages of this report, the soils of Willacy County are described in detail and their agricultural importance is discussed; their distribution is shown on the accompanying soil map; and their acreage and proportionate extent are given in Table 2.

TABLE 2.—*Acreage and proportionate extent of soils mapped in Willacy County, Tex.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Victoria fine sandy loam.....	20,272	9.7	Point Isabel fine sandy loam.....	576	0.6
Salty phase.....	6,848		High phase.....	1,792	
Victoria fine sandy clay loam.....	35,072	9.4	Point Isabel clay.....	2,816	.7
Light-colored phase.....	1,152		Tioeaco clay.....	3,648	.9
Victoria clay loam.....	64,896	21.8	Lomalto fine sandy loam.....	7,872	2.0
Salty phase.....	13,056		Lomalto clay loam.....	15,616	4.1
Light-colored phase.....	5,888	.9	Lomalto clay.....	7,808	2.0
Victoria clay.....	3,584		Lomalto and Nueces soils, undiffer-		
Willacy fine sandy loam.....	74,368	21.6	entiated.....	2,176	.6
Flat phase.....	4,480		Laredo silt loam.....	512	.1
Light-colored phase.....	1,536	.8	Nueces fine sand.....	11,200	13.0
Salty phase.....	1,408		Shallow phase.....	28,928	
Eroded phase.....	1,344	4.1	Prairie phase.....	6,016	3.1
Raymondville fine sandy clay loam.....	15,360		Shallow salty phase.....	3,840	
Salty phase.....	512	4.5	Dune sand.....	11,840	.1
Raymondville clay loam.....	15,936		Coastal beach.....	192	
Salty phase.....	1,024	.8	Total.....	384,640	
Raymondville clay.....	2,752				
Salty phase.....	320				

VICTORIA FINE SANDY LOAM

The surface soil of Victoria fine sandy loam, to an average depth of 10 or 12 inches, consists of dark-brown or black friable fine sandy loam which, in virgin areas, may be covered with brown or slightly dark-brown fine sand or loamy fine sand an inch or more thick. The surface soil is generally calcareous at its lower depth, and it may be calcareous throughout. This layer is underlain by dark-brown or nearly black friable calcareous fine sandy clay or clay loam, which may contain some small, soft, whitish lime accretions. Below a depth ranging from 16 to 24 inches is brown, slightly light-brown, or light-brown friable fine sandy clay or clay loam. This material is very calcareous as a rule, and some of it has a pinkish cast. Below a depth ranging from 30 to 36 inches is pinkish-buff or buff-brown friable, highly calcareous, fine sandy clay or clay loam containing large and small aggregates of soft, white, limy material. This material continues to a depth varying from 6 to more than 8 feet. At a depth of 12 feet, in the vicinity of Lyford and at Raymondville, brownish-gray fine sand was found. Within this sandy layer, near Raymondville, at a depth between 16 and 20 feet there is a stratum of salt water and in the vicinity of Lyford and Sebastian

a stratum of fresh water is found. When dry the upper layers of this soil assume an ashy cast, but when moist they are black or nearly black. Snail shells and fragments occur on the surface of the soil and to a depth of 1 or 2 feet. The fragments are more numerous in the lower part of the first foot and the upper part of the second foot.

In the more poorly drained areas the darker-colored layers continue to a greater depth, the layer of high lime accumulation represented in the typical soil by the pinkish-buff or buff-brown layer has a decidedly grayish cast, and the subsoil is less friable than in the typical soil.

The surface soil is high in content of dark-brown or black fine earth particles, which when moist adhere to and surround the sand grains and cause the soil to feel much heavier than a fine sandy loam. On drying, these clay particles still adhere to the sand. However, during driving rains or when the soil is blown by the wind, the clay particles become loosened, exposing the brown sand, and after remaining for some time without cultivation the dry surface may present a grayish-brown or dark grayish-brown appearance. Because of its high clay content, the soil is inclined to bake rather hard on drying, but on exposure to the air it soon slacks to a fine or medium tilth. When a mellow tilth is obtained, it is rather easily maintained, provided driving or very heavy rains do not occur. A slightly heavier draft equipment is necessary for the cultivation of this soil than its texture implies.

In the vicinity of Raymondville several newly cultivated areas of this soil, spotted with areas of lighter-colored soil than typical, were observed. Some of these lighter spots are inclusions of very small areas of the Hidalgo soils, and some of them are caused by bringing the lighter-colored subsoils to the surface in grubbing out trees.

Because the lower part of the subsoil was either deposited in salt water or influenced thereby areas of this soil not mapped with the salty phase, which occur east of the line from La Jarita ranch to a point about 2 miles east of Bowdens ranch, will be found to have a high salt content below a depth of a foot or two from the surface. Such areas are adapted to the production of the crops grown in the region so long as the salt content remains at the present level. The vegetation does not indicate this salty condition, but because of it the lower part of the subsoil is more grayish than is typical. The average content of salt in the typical soil is insufficient to have a toxic effect on crops commonly grown in this region.

The surface of this soil varies from smooth, with a very slight slope, to gently undulating. Drainage is also aided by the porosity of both surface soil and subsoil. The soil retains moisture very well under cultural methods practiced for its conservation but does not equal Willacy fine sandy loam in its moisture-retaining power.

Though occupying a smaller acreage than the clay loam and fine sandy clay loam members of the Victoria series, this soil is important in the agriculture of Willacy County. Areas are distributed over the entire alluvial plain. The largest are in the vicinity of Lyford. Small patches of Victoria fine sandy clay loam and Victoria clay loam, as well as small areas of Tiocono clay, were included with mapped areas of this soil.

Soil of this kind is well adapted to all the general farm crops, as well as to the vegetables grown in this county, and it is also adapted

to citrus-fruit production, especially in areas where a sufficient supply of fresh water is available to offset the deficiency in the annual rainfall. In the sweet-water region in the vicinity of Lyford and Sebastian it is particularly easy to supply fresh water. Some good citrus groves were seen growing on this soil, even where not irrigated, but the trees were smaller than those seen on the soil where sufficient moisture was obtained. Cotton, corn, the grain sorghums, Sudan grass, Rhodes grass, German millet, beans, tomatoes, and peppers do well. Yields fluctuate, depending on the amount of annual rainfall and its distribution throughout the season. In seasons of favorable moisture distribution from one-fourth to one-half bale of cotton to the acre may be obtained, from 25 to 30 bushels of corn, and two cuttings each of the sorghums, Sudan grass, Rhodes grass, and German millet. Yields of the sorghums, Sudan grass, and German millet vary from $1\frac{1}{2}$ to 2 tons to the acre at each cutting, and Rhodes grass produces from 1 to $1\frac{1}{4}$ tons to the acre at each cutting. Beans, mainly snap beans, yield from 85 to 125 hampers to the acre and tomatoes from 150 to 250 crates. In seasons of exceptionally well-distributed and plentiful moisture, these yields are increased, farmers reporting as much as three-fourths bale and more of cotton, from 45 to 50 bushels of corn, and three cuttings of the forage crops with maximum yields of each.

Land of this kind, cleared and improved, is held at prices ranging from \$100 to \$175 an acre, and unimproved land may be purchased at present at a price between \$60 and \$75 an acre. Location, character of improvements, and other features govern the selling price.

Victoria fine sandy loam, salty phase.—The main difference between Victoria fine sandy loam, salty phase, and the typical soil is the high content of water-soluble salts in the phase. The separation of the salty phase was based on the growth of sacahuista grass, a salt-loving plant, and tests with the electrolytic bridge for total salt content show that the presence of this grass is a positive indication. It is shown also that as a rule the minimum content of salt present where this grass occurs ranges from 0.1 to 0.15 per cent and upward. The average salt content of the material included in the salty phase, to a depth of 5 feet, ranged from 0.303 to 0.398 per cent, or more than five times the low content in typical Victoria fine sandy loam. Some included areas of a salty phase of Victoria clay loam are in the eastern part of the county. This high salt content is owing to the deposition of the soil material in the salt waters of the Gulf or to the subsequent influence of salt water on the soil particles and is so high as to practically prohibit the growth of most farm crops common in Willacy County.

In addition to the growth of sacahuista grass on this soil, it is noted that the growth of mesquite is less heavy and more stunted or is almost absent and that some of the grasses which grow on the typical soil are absent. However, buffalo grass is nearly everywhere present, with some needle grass where the salt content is not too high.

Owing both to a flatter surface and a heavier subsoil, drainage conditions are not so favorable in soil of this phase as in the typical soil. The pinkish and buff colors are not so bright in the layer of maximum lime accumulation, which has a slightly grayish cast.

Soil of this phase has practically no value except for pasture.

VICTORIA FINE SANDY CLAY LOAM

In the virgin condition, this soil, to a depth of 1 or 2 inches, consists of dark-brown or brown loamy fine sand or fine sand which is shifted by the wind following dry weather. This layer overlies dark-brown fine sandy clay, light clay loam, or clay loam which continues to a depth ranging from 10 to 15 inches and which is generally calcareous throughout or shows a reaction to hydrochloric acid above the bottom of the horizon. Below this layer is brown calcareous light clay loam or clay loam, which shows some specks of soft white lime. This layer becomes gradually lighter in color, until at a depth varying from 28 to 36 inches it gives way to pinkish-buff or buff-brown fine sandy clay or clay loam which continues to a depth of more than 6 feet. The lime content increases with depth, and at the 6-foot depth much soft white lime in large and small aggregates is present. Below the 30-inch depth the subsoil material is highly calcareous, and this layer represents the zone of lime accumulation.

When thoroughly dry the surface soil and upper subsoil layers assume a grayish cast, and the surface of cultivated fields presents a grayish-brown, dark grayish-brown, or ash grayish-brown appearance. When cultivated the surface soil to a depth of a few inches becomes incorporated with the clay loam. This results in a heavier-textured soil, which ranges from heavy loam to light clay loam. When wet the soil is rather sticky and somewhat plastic, owing to the high percentage of fine soil particles present. These soil particles are dark in color and have a tendency to adhere to the brown sand particles until they are removed by wind or rain. However, a thin coating of brownish fine sand remains on the surface.

Both surface soil and subsoil are friable and porous, readily allowing the downward passage of water. This porosity and the smooth but slightly sloping surface allow fair or good drainage, but this soil is not so well drained as Victoria fine sandy loam.

Some snail shells are generally present on the surface and in the upper part of the surface soil, and some shell fragments are found in most places in the lower part of the surface soil and the upper part of the subsoil.

A few comparatively small unusually flat areas with necessarily restricted drainage are included in mapped areas of this soil. Most of these included areas have a light-grayish cast, especially in the lower layers, and in this respect resemble Raymondville fine sandy clay loam. Included also are some areas in which the surface has a spotted appearance, owing to the inclusion of very small areas of the light-colored phases of the Victoria soils. The lighter color of some of the small areas is caused by bringing some of the lower lighter-colored soil to the surface during clearing operations.

In most places the surface soil and subsoil are friable, and the soil works fairly readily into a good tilth. When a good tilth is obtained it is easily maintained, except after driving rains. If plowed when too wet the soil breaks into rather large clods, but, on account of the high lime content, exposure to air and moisture soon causes the soil to break into fine clods or coarse grains. Fairly heavy draft and heavy machinery are necessary in cultivation. This soil is well supplied with organic matter. It absorbs moisture very well and retains

it well, especially where it is plowed thoroughly to provide a deep reservoir and where thorough cultivation keeps down the weeds and maintains a surface mulch.

This soil occurs mainly on the alluvial plain east of Raymondville. It is important agriculturally and is adapted to the same crops as Victoria fine sandy loam, though it is not so well suited to citrus trees, unless sufficient water is available to supplement the deficient rainfall. Crop yields are probably slightly less than on Victoria fine sandy loam except in years of favorable moisture supply and distribution.

The native vegetation consists principally of mesquite, ebony, brazil, retama, granjeno, chaparral, and prickly pear, with some Bermuda, buffalo, and needle grasses in addition to broom sedge, and, on the flatter areas, some white grass.

Land values are the same as for Victoria fine sandy loam under similar conditions.

The average content of water-soluble salts in this soil is low, though it is slightly higher than in Victoria fine sandy loam. However, to a depth of 5 feet the salts present are not injurious to growing crops. East of a line drawn from El Laurel ranch to San Andreas ranch are several areas in which the alkali content is high, generally below the second but in places below the first foot, owing to the deposition of the alluvial sediments in salt water or the subsequent influence of salt water on the soil material. The salt content to a depth of a foot or two is insufficient to harm the farm crops commonly grown in Willacy County.

Victoria fine sandy clay loam, light-colored phase.—Virgin Victoria fine sandy clay loam, light-colored phase, has a 1 or 2 inch surface layer of brown fine sandy loam or loamy fine sand. Below this, to a depth of 10 or 12 inches, is brown or light-brown light clay loam or clay loam, which is generally calcareous throughout or in the lower part. This passes into light-brown, yellowish-brown, slightly pinkish-brown, or buff clay loam, which is calcareous and which contains specks and streaks of soft white lime material. Below a depth ranging from 24 to 30 inches a highly calcareous buff-brown or pinkish-buff clay loam, generally containing soft white limy material, is present. This material continues below the 6-foot depth. A few small areas in which the soil has a distinct loam texture are included with this light-colored soil in mapping.

In most areas of this soil numerous snail shells are scattered on the surface and through the soil to a depth of 1 foot. Below this depth fewer shells but more fragments are present.

In some places the surface of newly plowed fields presents a spotted appearance. This is owing to some extent to variations in color of the surface soil, caused by the intermixture of small patches of the dark Victoria fine sandy clay loam or to grubbing operations, when the lighter-colored material from below the surface is thrown out on the surface, to remain until the field has been plowed and cultivated sufficiently to give the surface a uniform color. These spotted areas are observed only when the fields are first cultivated.

The surface of this soil varies from nearly level to gently undulating. The soil occupies an intermediate position between the fine sandy loam and the clay loam members of the Victoria series with

regard to drainage. Though it is rather more open structured it is slightly less well drained than Victoria fine sandy loam. The total acreage of this soil in Willacy County is small. Most of the areas occur on the alluvial plain between Raymondville and Lasara.

Aside from a slightly greater difficulty in handling this soil, there is little agricultural difference between it and Victoria fine sandy loam. It has a slightly lower organic-matter content than typical Victoria fine sandy clay loam, but its agricultural adaptations and the yields obtained are very similar to those of the typical soil. The content of water-soluble salts is low.

In its virgin condition this soil supports a vegetation similar to that growing on the included areas of Victoria fine sandy loam, with the addition of horsemint, Texas whiteleaf, sweet brush (*yerba dulce*), and cat's-claw.

VICTORIA CLAY LOAM

The surface soil of Victoria clay loam, to a depth varying from 8 to 12 inches, consists of dark-brown, nearly black, or black clay loam, over the surface of which there may be a one-half or 1 inch layer of brown or dark-brown loamy fine sand or fine sand. The typical surface material gives way to dark-brown or brown clay loam or clay which becomes gradually lighter in color with depth. At a depth of about 3 feet the material consists of yellowish-brown, buff-brown, or pinkish-buff clay loam or clay, which continues below the 6-foot depth. On drying the surface soil and upper part of the subsoil assume a distinctly grayish or ashy cast. Where drainage is rather poor a grayish cast is noticeable throughout the subsoil.

This soil is increasingly calcareous from the surface downward, small white lime specks being found within a depth of 1 foot in some places. In the lower part of the subsoil, which constitutes the zone of high lime accumulation, numerous large and small soft white lime aggregates are commonly present. Some snail shells and fragments of shells occur in most places on the surface and to a depth of 2 feet.

When wet the surface soil and subsoil are sticky and rather plastic, and if plowed when too wet the material breaks up into large clods. The slaking caused by the high lime content and exposure to air and moisture soon reduces these clods, and fields are fairly easily brought into good tilth. When once procured, good tilth is easily maintained unless driving or heavy rains occur.

The surface of this soil ranges from nearly level to smooth with a slight slope which is generally sufficient, combined with the porosity of the subsoil, to take care of all except heavy or continued rains. The more level areas are in the eastern part of the county. In slight depressions where the subsoil is generally rather heavy water may stand for a long time following rains. This soil lies lower than the fine sandy loam and fine sandy clay loam members of the Victoria series. It is the most extensive soil mapped in Willacy County and is important agriculturally, although most farmers prefer the lighter-textured Victoria soils. Large areas occur in the south-central and eastern parts of the county.

Those areas in the vicinity of Arroyo Colorado are subject to occasional overflow. Areas occurring east of Lasara, east of the old Rio Grande channel, may be covered by a thin layer of water when a great volume of water is diverted up the old Campacuas channel

north of Mercedes. However, little damage is caused by these rare overflows, and floods in the old channel will probably be prevented altogether by the work now in progress along the river.

The native vegetation on this soil includes mesquite, some ebony, brazil, and retama, some huisache in low areas, and an undergrowth of prickly pear, chaparral, cat's-claw, and small granjeno. Buffalo grass makes a thick carpet where the tree and brush growth is lacking, and white grass, smut grass, and Egyptian grass are also seen.

Under normal nonirrigated conditions the content of water-soluble salts in this soil is insufficient to be harmful to the crops commonly grown. However, areas extending west for some distance from the areas mapped as the salty phase have a rather large salt content at a depth of 1 or 2 feet below the surface. Thorough saturation of these areas by irrigation might cause the content of salt to rise to such an extent that the soil would become toxic to plant growth. Areas thus affected lie east of a line from Bowdens ranch to Paso Real.

The structure of the subsoil is not favorable to the storage of a large amount of moisture. Where a deep reservoir is provided by deep plowing and conservation of moisture is accomplished through keeping down weeds and preventing evaporation this soil will retain moisture for some time after the cessation of rains, but it is inclined to be more droughty than the fine sandy loam and fine sandy clay loam members of the Victoria series. Heavy draft and farm-machinery equipment are necessary for the successful handling of this soil.

This soil is suited to all the staple farm crops grown in this region, to vegetable crops, and to citrus crops, provided fresh water is available to make up for the deficiency of rainfall necessary for best growth. In favorable seasons yields are much the same as those obtained on Victoria fine sandy loam, but in dry years much smaller yields will be obtained. Potatoes seem to do better than on the lighter-textured soils, yields of 160 bushels to the acre having been obtained in a favorable season. The lighter-textured soils are preferred for citrus trees.

Land values are the same as for Victoria fine sandy loam and Victoria fine sandy clay loam, depending on improvements, location, and other features.

Victoria clay loam, light-colored phase.—The surface soil of Victoria clay loam, light-colored phase, consists of brown, friable, calcareous clay loam from 8 to 12 inches thick. This grades into light-brown, calcareous clay loam, and this, at a depth varying from 24 to 30 inches, into yellowish-brown, pinkish, or buff-brown clay loam which continues below the 6-foot depth. This lower layer is highly calcareous and represents the zone of lime accumulation. The upper part contains small aggregates of soft white lime material, which generally become larger and more numerous with depth. A few small specks and streaks of lime may occur between depths of 1 and 2 feet. A large number of snail shells and fragments of shells are found to a depth of a few feet. The shells are most numerous on the surface and to a depth of 1 foot, and the fragments occur chiefly near a depth of 1 foot.

This soil occurs in rather large areas on the alluvial plain. The largest area is several miles northeast of Raymondville, in the

vicinity of Marena ranch. The soil contains more organic matter than Raymondville clay loam but less than Victoria clay loam.

The surface is mainly smooth, with a slope sufficient to aid in drainage. As a rule the surface soil and subsoil are rather friable and porous, readily allowing the downward movement of moisture. Drainage is therefore fair or good. A few included depressions, too small to show on the map, grade toward Raymondville clay loam.

The content of total water-soluble salts in this soil is low. An area $1\frac{1}{2}$ miles north of Willamar shows a high salt content below a depth of 3 feet. A high salt content at this depth is not apt to affect the farm crops commonly grown under nonirrigated conditions, but the application of excessive irrigation water might, through a rise of the salts, adversely affect the surface soil.

Seasonal variations in rainfall and other climatic features cause fluctuations in crop yields. The soil is suited to cotton, corn, the sorghums, onions, beans, and tomatoes. Citrus fruits would do well where sufficient fresh water is available to supplement the annual rainfall. This soil is inclined to be more droughty than Victoria fine sandy clay loam during years of slight or poorly distributed rainfall.

Under favorable moisture conditions the average yield of cotton ranges from one-fourth to one-half bale to the acre and of corn from 20 to 30 bushels. Two cuttings of the sorghums, each ranging from $1\frac{1}{2}$ to 2 tons to the acre, and some pasture following the second cutting, are obtained. Onions average about 100 crates to the acre, tomatoes between 150 and 250 crates, and snap beans from 85 to 100 hampers. In years of slight or poorly distributed rainfall, these yields are materially reduced, and in years of exceptionally favorable rainfall more than three-fourths bale of cotton to the acre is obtained, and yields of 40 or 45 bushels of corn are reported. In such seasons three cuttings of sorghum for hay are usually obtained.

Land of this kind in the virgin condition is covered with mesquite, ebony, brazil, ratama, chaparral, horsemint, sweet brush (yerba dulce), cat's-claw, prickly pear, and Texas whiteleaf. The grass growth, which is usually scant owing to the heavy underbrush, consists mainly of buffalo grass, with some broom sedge, needle grass, and sandspur.

Where cleared and improved this land sells at prices ranging from about \$75 to \$150 an acre. Unimproved land may be bought for \$50 or \$100 an acre.

Victoria clay loam, salty phase.—At the extreme eastern limit of the alluvial plain, where the flood waters of the Rio Grande had lost their force and of necessity deposited the fine soil particles which were held in suspension until this point was reached, is a band, varying from 1 to 3 miles in width, of the salty phase of Victoria clay loam. In general the soil is similar to the typical soil, though owing to the prevailing flat surface and poorer drainage, this soil in places appears grayish.

The chief difference between this salty soil and the typical soil lies in the high content of water-soluble salts in the phase, evidenced by tests with the Wheatstone bridge and by the heavy growth of sacahuista, a grass indicating the presence of salt in amounts exceeding 0.15 per cent. The salt content in this phase of soil is from two to three or more times that of typical Victoria clay loam. Common salt is the principal salt present, since the fresh-water sediments were

here undoubtedly deposited in the waters of the Gulf or were strongly affected by salt water at some time or other. The average water-soluble salts content present in the areas mapped as a salty phase is sufficient to affect adversely if not to prohibit the growth of most of the crops common to Willacy County.

In addition to the growth of sacahuista grass there are small scattered mesquite trees but no prickly pears. Some white grass and smut grass were seen. Where only a medium salt content is found in the surface soil and in small areas devoid of trees and brush, buffalo grass makes a thick growth.

Areas of this soil are valuable only for pasture land.

VICTORIA CLAY

Scattered over the eastern edge of the alluvial plain, chiefly in association with Victoria clay loam and Raymondville clay loam, are small or fairly large flat areas, the soil of which consists of black or nearly black clay continuous without change to a depth of 12 or 15 inches. The soil is calcareous and contains some small specks of soft white limy material. This layer gives way to dark-brown clay, also calcareous and containing many small soft white lime aggregates. The clay becomes lighter with depth, until at a depth varying from 24 to 30 inches it grades into brown calcareous material, in which there is a generous sprinkling of slightly larger aggregates of calcareous material. Between depths ranging from 32 to 40 inches and more than 6 feet is buff-brown, pinkish-buff, or, here and there, grayish buff-brown highly calcareous clay containing many large and small soft white lime accretions. This layer is the zone of high lime accumulation in this soil.

When dry the upper part of the soil assumes a grayish or dark-grayish cast, the color of the surface soil being ash black. The grayish color of the lower part of the soil is generally an indication of poor drainage. The surface of this soil is prevaillingly flat or slightly depressed. In consequence, surface drainage is restricted, and the heavy texture of the soils retards underdrainage. Water may stand on the surface for long periods after rains. When wet this soil becomes very plastic, sticky, and boggy, and when dry it cracks into large clods.

All of this soil mapped was covered with native vegetation, chiefly mesquite, with some granjeno, an occasional retama, and huisache. The undergrowth is thin or lacking, and on many small areas no tree vegetation is present. Some areas support a luxuriant growth of running mesquite and buffalo grass, particularly where the moisture supply and distribution are favorable.

Though no tests were made, it is probable that the subsoil below a depth of 1 or 2 feet has a high content of water-soluble salts.

WILLACY FINE SANDY LOAM

In its typical development the topsoil of Willacy fine sandy loam consists of dark grayish-brown or dark-brown fine sandy loam underlain, at a depth ranging from 12 to 20 inches, by brown fine sandy clay loam or clay loam. The grayish cast is noticeable when the soil is thoroughly dry. This layer becomes gradually lighter in

color and, at a depth varying from 24 to 30 inches, grades into light-brown friable clay loam which in some places is slightly calcareous at the greater depths. Below a depth between 30 and 36 inches is yellowish-brown, cream-colored, or buff-brown clay loam, which is highly calcareous, and which in many places contains soft whitish lime material and some hard white lime concretions. Along the western county line this calcareous material continues to a depth of more than 40 feet without much change. In the eastern part of the county, however, this material is underlain, at a depth varying from 10 to 20 feet, by yellow, calcareous, rather loose fine sand, in some places interstratified with buff-brown or pinkish highly calcareous clay loam which contains whitish lime concretions or seams in which a large number of lime concretions, some of them an inch in diameter, occur. Where the buff-brown or yellowish-brown calcareous material extends to a considerable depth in the western part of the county, such seams are very common at the greater depth. No well-defined caliche layers or beds occur under this soil. In very few places does the surface soil effervesce with hydrochloric acid above the 24-inch depth.

Close examination of the surface soil shows a high percentage of silt and clay particles. Most of these fine particles are dark-brown, but some are nearly black. The fine sand grains are mainly brown or grayish brown. When moderately moist the fine soil particles adhere to the sand grains, giving the soil layer a dark color. When these fine particles are removed by beating rains or by wind movement the surface 1-inch layer becomes light brown or grayish in color and fine sand or loamy fine sand in texture. The original color and texture are restored by cultivation and moderate rains. In virgin areas grayish-brown or brown fine sand is present over most of the surface, especially around trees or shrubs where it has been accumulated by the winds. The high percentage of silt and clay particles, particularly in virgin areas and in fields which have not been cultivated for some time, also causes a hardening of the soil following long periods of dry weather. This hardened layer generally underlies the loose surface material at a depth of 1 or 2 inches, is about 3 or 4 inches in thickness, and grades below into the typical mellow, friable soil material. Following an extended dry spell the surface of the soil assumes an ashy cast.

The surface relief of Willacy fine sandy loam varies from nearly level to gently undulating in the large area in the western part of the county and in the larger areas mapped in the eastern part. In small, isolated areas of this soil scattered over the central and eastern parts of the county, a low mound relief prevails. This relief, together with the porosity of the surface soil and subsoil, causes the soil to be well drained, very little run-off occurring except during very heavy rains or after continued rains.

In the western part of the county this soil represents the eastern edge of the alluvial fan extending eastward from the Nueces-Rio Grande divide, and some of the areas in the central and eastern parts of the county may be isolated remnants of that fan. Other smaller areas represent alluvial material deposited by the Rio Grande or other streams when these streams were flowing at a higher level than at present. These areas are above the level of the main alluvial

plain and are therefore not subject to inundation by such flood waters as are diverted through the old Campacuas channel. Wind action has taken part in the formation of this soil, as is evidenced by the numerous potholes and adjacent mounds occurring in the principal areas. The removal by winds of material from such potholes on the true alluvial plain has given rise to areas of typical soil on the leeward side of the potholes. Where of sufficient size such depressions have been mapped as Tiocano clay or Willacy fine sandy loam, flat phase, but they are generally only one-half acre or so in extent. Following heavy or continued rains these depressions hold water for long periods of time.

The light texture of the soil, its thickness, and the friable consistence and open structure of the subsoil render this soil very retentive of moisture. It also readily supplies plant life with water from the lower levels through capillarity. Under cultural methods designed to create a deep storage reservoir and to prevent undue evaporation, this soil will retain moisture long after most of the soils of the county become droughty. For this reason Willacy fine sandy loam is favored for farming operations.

The typical growth on virgin areas of Willacy fine sandy loam consists of mesquite, mainly fair sized and large, with an undergrowth of prickly pear. (Pl. 1.) The grass growth consists mainly of needle grass, Bermuda grass, and some mesquite grass and sandspur. In the eastern part of the county many other trees and shrubs are mixed with this typical growth, among them ebony, brazil, and such shrubs as white chaparral, coyotillo, wild olive, and Texas whiteleaf. In the summer of 1926 about 75 per cent of this soil was in its virgin condition, but large areas were being cleared.

This soil lends itself readily to all cultural operations, and the range under which cultivation may be carried on is wide. The land becomes sufficiently dry soon after normal rains to allow cultivation, and it never becomes so intractable following continued dry weather as to make plowing impossible. This feature, together with its moisture-holding capacity, renders it a valuable soil for agricultural purposes. Cotton is the chief crop grown, and over a long period of years average yields, according to estimates of farmers, of one-fourth bale to the acre have been obtained. In years of favorable moisture distribution average yields of one-half bale have been obtained, with individual yields ranging from three-fourths to 1 bale to the acre for small fields being reported. Corn yields from 20 to 30 bushels to the acre, and in good seasons as much as 40 or 45 bushels have been obtained. In droughty seasons or seasons in which insect infestation is serious, yields are below the average. Red top is the principal grain sorghum grown, and with average distribution of moisture a good spring crop and a fair summer crop are obtained. In years in which moisture is received during the late summer months a third crop or some pasturage is obtained. Yields varying from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons to the acre at each cutting over a series of seasons have been reported. Fall sorghums may be planted as late as September 15, if there is sufficient moisture in the soil for growth, and be ready for cutting in 60 days, when yields of $1\frac{1}{2}$ or 2 tons to the acre are common. Pasturage is afforded until killing frosts occur. Similar results are had with darso, feterita, hegari, and schrock. The grain sorghums are not commonly grown for grain, but yields ranging from

15 to 25 bushels to the acre at each of the two cuttings for seed have been obtained in good seasons. When fall rains occur, some pasture or a third cutting for hay may be obtained.

Winter vegetables grown on this soil under dry-farming conditions include onions and snap beans. Yields vary with the season, but yields of 150 crates of marketable Bermuda onions and slightly less of the Crystal Wax variety are obtained. Beans are grown generally in small patches, and yields range from 75 to 125 hampers to the acre. This soil is well adapted to early spring and late fall garden vegetables.

Citrus trees on this soil thrive as well as, or better than, on any other soil in the county. Though the normal rainfall is less than is required for the best tree growth, the moisture-holding capacity of Willacy fine sandy loam is an asset. The low average content of water-soluble salts is also favorable.

Improved farms of this soil sell at prices ranging from \$75 to \$150 an acre, and unimproved lands command from \$40 to slightly more than \$60.

In that part of the county where the salty phase soils are adjacent to areas of the typical soil a comparatively high salt content is present at a depth of about 5 feet, whereas to a depth of 2 or 3 feet the soil may be but slightly affected. The salt content at this depth will not affect the ordinary farm crops under nonirrigated conditions, but citrus trees may be injured.

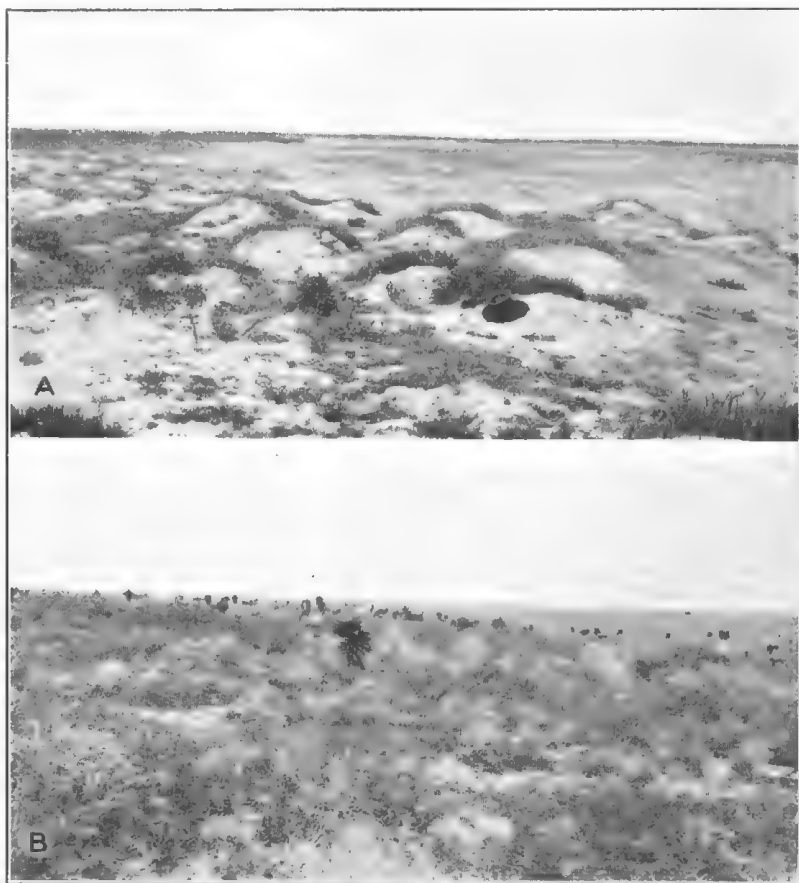
Willacy fine sandy loam, flat phase.—The surface soil of Willacy fine sandy loam, flat phase, consists of grayish-brown or dark grayish-brown fine sandy loam or heavy fine sandy loam from 9 to 15 inches thick. This is underlain by brown, rather compact clay loam or clay, which becomes lighter in color with depth and grades, at a depth of about 30 inches, into light-brown or yellowish-brown clay loam or clay which is slightly more friable than the upper part of the subsoil but not so friable as that under typical Willacy fine sandy loam. Below a depth of about 36 inches is buff-brown or slightly pinkish-buff clay loam or clay which continues to a considerable depth. No effervescence is noted above the 30-inch depth, though the buff-brown layer lying at about the 36-inch depth is rich in lime and usually contains some soft lime concretions.

Soil of this phase occurs principally several miles northeast of Raymondville, in close proximity to the Raymondville soils. The surface of this soil is prevailingly level, and the run-off of surface waters is slight. The compact subsoil prevents rapid downward drainage, and water remains on the surface for some time following heavy rains. When once saturated the subsoil becomes plastic and remains so for a long time. This causes the surface soil to become soggy. On drying, however, both surface soil and subsoil become hard and compact. Soil of this phase is sometimes termed hardpan land.

In the virgin condition, this soil supports a growth of small mesquite and of stunted prickly pear. The chief grass growth is broom sedge, smut grass, and a medium high, rather coarse bunch grass known locally as wild rye. Land of this phase is not favored for cultivation, on account of its low moisture-retaining capacity, its tendency to puddle if cultivated when too wet and to crack into intractable clods if plowed when dry and hard, and its rather poor



Predominant growth on Willacy fine sandy loam



A, Incipient dune on Point Isabel fine sandy loam; B, typical growth on the older, higher clay dunes on Point Isabel fine sandy loam

drainage. Crop yields are below the average obtained on the typical soil, and vegetables do not produce so well.

Included with this soil in mapping are several small depressed areas, in or adjacent to areas of typical Willacy fine sandy loam, from which most of the surface material has been removed by wind action. The surface soil of these areas is grayish-brown, brownish-gray, or gray fine sandy loam, from 4 to 6 inches thick. This layer is underlain by brownish-gray, dark brownish-gray, or gray clay loam, which continues to a depth of more than 4 feet. It may become slightly lighter colored with depth and in most places is calcareous below the 2-foot depth. Such areas are poorly drained, and water usually stands on them following rainy seasons. These depressions are similar to those occupied by Tiocano clay.

Willacy fine sandy loam, light-colored phase.—In its virgin condition Willacy fine sandy loam, light-colored phase, has a loose light-brown, grayish-brown, or brown fine sand surface soil from 2 to 8 inches thick, which is underlain by dark-brown or nearly black loamy fine sand or fine sandy loam continuous to a depth ranging from 14 to 18 inches. This layer is generally underlain by dark-brown or dark grayish-brown fine sandy clay loam or clay loam from 2 to 4 inches thick. At a depth varying from 20 to 24 inches the material gives way either to clay loam or heavy clay loam of grayish-brown, gray, or bluish-gray shade, in some places mottled with brown or yellow, or to slightly grayish buff-brown clay loam continuous to a depth of 4 or 5 feet, which is generally calcareous at about the 3-foot depth. Where the first-mentioned subsoil material occurs it generally continues without much change to a depth varying from about 40 to 48 inches, where it gives way to the calcareous grayish buff-brown clay loam. Some lime concretions are present in the lower part of the subsoil in most places.

Soil of this phase has a prevailing level or nearly level surface. Though moisture permeates readily through the surface soil material it is somewhat retarded by the subsoil. Drainage is only fair. Following rainy spells the surface soil sometimes becomes saturated, and the subsoil becomes rather plastic. When dry the subsoil has a tendency to become hard and compact.

The tree growth on this land consists principally of mesquite, with granjeno, brazil, and ebony in places, and an undergrowth of prickly pear, cat's-claw, white chaparral, sweet brush, and horsemint. The grass growth consists principally of mesquite grass, needle grass, and broom sedge.

Areas of this soil are mapped east of Yturria near the northern county line. The total area is small. Small patches are included in areas of typical Willacy fine sandy loam where it approaches the Nueces soils. This soil seems to be a mixture of Willacy and Nueces soils, the upper sandy layer being similar to the Nueces, the second layer similar to the Willacy, and the grayish or grayish-brown clay loam subsoil with brown and yellow mottles being similar to the lower layers of the Nueces soils. The lower calcareous layer is similar to that under the flat-phase Willacy soils. Some typical Willacy fine sandy loam is also included in mapping.

All this land is used for pasture at present. With favorable moisture conditions the staple crops of the county should do well. A fair

or good organic-matter supply is present where the loose sandy material is not too deep.

Willacy fine sandy loam, salty phase.—Willacy fine sandy loam, salty phase, consists of typical Willacy fine sandy loam which either has been subjected to inundation by salt water or in which the soil material was wholly or partly deposited in shallow salt water, leaving sufficient salt in the soil to promote the growth of salt-loving vegetation. Areas of this salty soil are in the eastern part of the county at an elevation averaging about 15 feet or less above sea level, and lie between the soils of the alluvial plain and those of the marine plain.

Very little difference is apparent in soil of this phase and the typical soil. The chief difference is that soil of the salty phase has a less friable, more compact subsoil and a slightly shallower surface soil. A difference in the vegetable growth is most pronounced, and this figured largely in the separation of the phase from the typical soil. The mesquite growth is smaller and less abundant, as is also the growth of prickly pear, most of the undergrowth is smaller, ebony is generally lacking, and sacahuista grass is abundant.

The content of water-soluble salt in this soil ranges from 6 to 10 times that in typical Willacy fine sandy loam. The average content for the typical soil to a depth of 5 feet is 0.069 per cent, and soil of the phase averages 0.629 per cent.

All this soil is included in pasture land. Bermuda grass, mesquite grass, needle grass, and sandspur are the principal grasses, together with some broom grass.

Willacy fine sandy loam, eroded phase.—Adjacent to La Sal Vieja is a narrow band of eroded material, on the slope from the normal level to the shore of these intermittent salt lakes. Drainage waters have removed a large part if not all of the surface soil and in places some of the upper part of the subsoil, and have cut numerous small gullies. Dependent on the extent of erosion, various areas of rather typical Willacy material are present. Most of the soil of this phase consists of brown fine sandy clay loam or clay loam, grading at a depth varying from 10 to 20 inches into yellowish-brown or buff-brown calcareous clay loam which continues to a depth of more than 3 feet without change. In some places rather loose grayish-brown or light-brown fine sand has been washed over the surface, and in other places typical Willacy fine sandy loam, a few inches thick, is present.

The principal tree growth consists of mesquite, and there is very little if any undergrowth except prickly pear. Bermuda grass grows where the surface is not too badly washed. This eroded soil is nonagricultural.

RAYMONDVILLE FINE SANDY CLAY LOAM

In its virgin condition the 1 or 2 inch surface layer of Raymondville fine sandy clay loam consists of grayish-brown, dark grayish-brown, or brownish-gray fine sandy loam, or loamy fine sand. This is underlain by ash-gray, light ash-gray, dark brownish-gray, or brownish-gray clay loam, which continues to a depth varying from 30 to 40 inches with little change, except possibly the acquisition of a brownish or yellowish tinge in the lower part. This layer is generally underlain by light grayish-brown or yellowish-gray clay or clay loam, which at a depth of about 4 feet grades into grayish buff-brown

clay continuous without appreciable change below the 6-foot depth. In a few places below the 30-inch depth pinkish-gray or brown clay is present. This gives way, at a depth of 4 feet, to buff-brown or slightly grayish buff-brown clay which continues below the 6-foot depth. The soil is calcareous from the surface downward and is highly calcareous below the 30-inch depth, where soft white lime specks are noticeable. As a rule these spots become more numerous and larger with depth. Cuts show a large number of snail shells in the first foot of soil, less in the second foot, and practically none below a depth of 2 feet, though at this depth fragments of snail shells are numerous.

When dry, cultivated fields acquire a distinctly ash-gray cast. Owing to the high content of snail shells, freshly cultivated fields have a whitish appearance following heavy rains.

On cultivation the surface 1 or 2 inch layer of fine sandy loam or loamy fine sand becomes mixed with the underlying clay loam. This results in a surface soil, 5 or 6 inches thick, of heavy fine sandy loam, heavy loam, or in some places light clay loam. Where the light clay loam occurs the surface covering of sandy material is thin or has been removed by the wind. The subsurface layer, which consists of clay loam, becomes very plastic when wet. When wet, cultivated fields appear heavier in texture than they really are. When thoroughly saturated this soil, to a depth of a few feet, becomes very sticky, plastic, and boggy, and though the immediate surface dries out quickly the underlying material may remain wet and boggy for some time. Cultural operations are hampered during wet weather and for a short time thereafter, but not so much so as on the clay loam and clay members of the Raymondville series. On drying the soil cracks rather badly but not to so great an extent as does the clay loam.

This soil, in association with Raymondville clay loam and Raymondville clay, occupies the obscure old channel of the Rio Grande extending northward from Mercedes, Hidalgo County. This soil appears to lie slightly lower than the Victoria soils but not so low as Raymondville clay loam. It is reported that the last severe flood, in 1921, covered the land only to a depth ranging from 6 to 12 inches. Future floods may be prevented by the flood-prevention work in progress in Hidalgo County. The surface of this soil is prevailingly very flat, and this, together with the heaviness of the subsoil, causes drainage to be very poor. When dry the soil absorbs water very readily, but when saturated it hardens and becomes compact. Large clods form when the land is plowed. However, owing to the high content of lime, these clods break down readily to small and medium-sized clods when exposed to air and moisture for some time. Unless packed by driving rains, after the soil has been reduced to favorable tilth it is easily maintained in that condition.

This soil has been mapped in several large and numerous small areas, the main areas being located about 2 miles east of Lasara and 3 and 6 miles north of Sombrerito School.

Tests for water-soluble salts show that the average content in this soil is rather low, the alkali present in most places being insufficient to affect adversely any of the crops grown in Willacy County at this time. However, the poor drainage and the unfavorable physical condition of the soil render it poorly adapted to farming. In an area

mapped in the vicinity of San Andreas ranch a high salt content will probably be found below a depth of 1 or 2 feet, since this area is but slightly elevated and adjoins areas in which salt is known to exist in fairly large quantities near a depth of 5 feet. In this position non-irrigated growing field crops would hardly be affected, but with irrigation the salt would tend to rise and cause injury.

Cotton, corn, the sorghums, and onions are the chief crops suited to this soil. Favorable moisture conditions are necessary for the best yields. Corn fires easily following continued dry weather. Yields are much the same as on Raymondville clay loam, and land values are practically the same.

Probably less than 15 per cent of the total area of this soil is under cultivation, and the remainder is used for pasture. This gray sandy soil, as it is locally called, is not especially preferred for farming purposes. In its virgin condition it supports a sparse growth of small mesquite, some huisache, and retama, a few prickly pear, and some chaparral, with white grass, broom sedge, and spots of Bermuda, buffalo, and mesquite grasses comprising the undergrowth. In some areas smut grass is common, as well as several grasses of the *Velota* family (for which no local name could be obtained), and Egyptian grass, a medium short grass with wheatlike heads. In the areas where the trees are scattered, the grass growth is rank and much pasturage is afforded during years when the moisture distribution is favorable.

Raymondville fine sandy clay loam, salty phase.—The chief differences between Raymondville fine sandy clay loam, salty phase, and typical Raymondville fine sandy clay loam are in color, character of vegetation, and salt content. The chief color difference is in the lower part of the subsoil, where the buff brown of the subsoil and the pinkish cast present in the typical soil in many places are absent. Soil of this phase has a grayish cast throughout, with faint tinges of brown and yellow at a depth varying from 30 to 40 or more inches. The vegetable growth varies in that huisache and retama are almost entirely absent on most areas. Prickly pear is seen in few places, and much of the grass growth is sacahuista grass, the vegetative indicator of a high salt content. Small patches of buffalo grass are common on the more open areas.

The total area of land of this phase is very small. The small isolated areas are scattered over the eastern alluvial plain. The land is valuable only for pasture.

RAYMONDVILLE CLAY LOAM

The surface soil of Raymondville clay loam consists of grayish-brown, dark grayish-brown, or brownish-gray clay loam or heavy clay loam, from 8 to 12 inches thick. It is underlain by light brownish-gray or gray clay or heavy clay loam, which in some places has a yellowish or light-brownish tinge. This layer continues to an average depth of 30 inches, where it is underlain by yellowish-gray or brownish-gray clay in which the yellowish or brownish cast increases in intensity with depth. Where drainage is good a pinkish tinge may take the place of the yellow or brown. In the more poorly drained areas the lower part of the subsoil is distinctly grayish

or ash colored. The soil is calcareous throughout. The content of lime carbonate increases with depth, and at and below a depth of 3 feet the soil material is very highly charged with lime.

The outstanding characteristic of this soil is the occurrence on the surface and to a depth of 1 foot of a large number of snail shells which give the surface of newly plowed fields a spotted or whitish appearance after a rain. Cuts in this soil also present a white-spotted aspect. Near a depth of 1 foot, fragments of snail shells are numerous, the perfect shells decreasing in number. The fragments become very much less numerous near a depth of 2 feet, and here soft, white, limy specks are common. At a depth varying from 5 to 6 feet the limy specks, in addition to thin streaks of lime, are numerous, and a few hard lime pebbles or concretions are present.

When moist the brownish color of the soil is accentuated, but on drying the gray or ash tint is predominant. The surface of plowed fields which have been exposed to the sun and rains for some time without cultivation assumes a light-gray or light ash-gray color.

In the western part of Willacy County this soil occurs as the northward extension of the old Rio Grande channel which branches northward from Hidalgo County. As a rule the surface lies slightly lower than the associated soils, hence when the Rio Grande overflows sufficiently to force the water northward through this old channel, the overflow waters follow the areas occupied by this and other Raymondville soils, spreading out from them over the adjacent country. Before reaching the Hidalgo-Willacy County line southeast of Lasara several arms branch off eastward from this main channel, which continues northward to a point about 6 miles northwest of Raymondville, where it swings eastward. Beyond this point the location of this old channel is absent or obscure to a point 8 miles northeast of Raymondville, where the old channel is again occupied by this and other Raymondville soils. In many places areas of this soil do not appear much lower than the adjacent Victoria soils. Overflows on this soil are very rare and may be prevented altogether by the flood-protection work now in progress along the Rio Grande.

This soil is not favorable to agricultural operations, since when wet it becomes very plastic and boggy and when dry it becomes very hard and cracks widely and deeply. However, the high lime content causes the soil to break down readily under exposure to air. It is then readily tilled and in the absence of driving rains thereafter is easily kept in good tilth. The moisture-holding capacity is low, and the soil is inclined to be droughty. Corn fires on this soil much earlier than on any other soil in the county. If the season is wet during the time when crops are usually cultivated, it is impossible to enter the fields for a long time following cessation of the rain, and crops suffer severely from weed growth.

Probably less than 10 per cent of the total area of this soil in Willacy County is under cultivation at present. In its native condition the land supports a growth of mesquite, the two varieties of retama common to the county, much huisache, a few prickly pear, considerable small bushy growth, broom sedge, and white, sweet, mesquite, buffalo, and Bermuda grasses. Cotton, corn, the grain sorghums, and onions are the chief crops grown on this soil. In years of favorable moisture distribution yields ranging from one-fourth to one-half bale of cotton to the acre may be obtained, and some higher yields are

reported. Corn yields from 15 to 30 bushels to the acre, and grain sorghums from 15 to 25 bushels, the maximum yields being obtained in seasons of most favorably distributed moisture. Sudan grass does well when sufficient moisture is present, and two crops of $1\frac{1}{2}$ or 2 tons each to the acre may be obtained, or one cutting and some pasturage. In dry years this crop fires badly and in some years is severely affected by rust. The grain sorghums, when cut green for feed, are cut from one to three times during the season, depending on the rainfall. Under best conditions yields of these crops range from $1\frac{1}{2}$ to $2\frac{1}{2}$ tons to the acre at each cutting. On account of its stickiness and plasticity, particularly during the wet winter months, it is rather difficult to grow onions successfully on this soil, and in wet seasons more splits and doubles are apt to occur than on better-drained soils. Yields of 125 crates to the acre have been reported, but from 85 to 100 crates of marketable onions is an average yield.

Land of this kind varies in value, depending on location, whether cleared or virgin, and on character of improvements. Cleared, improved land is held at prices ranging from \$130 to \$150 or slightly more an acre.

Raymondville clay loam, salty phase.—Raymondville clay loam, salty phase does not vary widely from the typical soil. As a rule the gray color is more pronounced and the subsoil is apt to be tougher than typical.

The growth of sacahuista grass indicates a high salt content. No test was made of the areas mapped as the salty phase, but tests of the fine sandy clay loam member of the Raymondville series indicate that this soil is too high in salt to be utilized for any purpose except pasture.

The vegetation on this soil consists of a rather sparse growth of mesquite, with some huisache, considerable white grass, some buffalo grass, and sacahuista grass.

It is probable that the area of typical soil mapped east of Bowdens ranch in some places below the 2-foot depth contains considerable salt, since the area lies within the region west of the general area of salty phases, where tests have shown that a high salt content occurs at a depth of 1 or 2 feet.

RAYMONDVILLE CLAY

To an average depth of about 10 or 12 inches the surface soil of Raymondville clay consists of gray or dark-gray clay, tinged in places with brown or brownish gray. The brown color is more pronounced when the soil is moist. The subsoil consists of gray, light gray, or ash brownish-gray clay, generally compact, which at a depth varying from 30 to 40 or more inches grades into light brownish-gray, grayish-buff, pinkish light-gray, or, rarely, buff-brown clay which continues to a depth greater than 6 feet. When dry the entire soil, particularly the upper few inches, assumes an ash-colored or light-grayish cast, and the surface soil, when plowed and exposed to the rain and sun for some time without cultivation, becomes light ash gray. The soil is calcareous throughout and is very highly calcareous below the 24-inch depth.

On the surface and to a depth of 1 foot snail shells are numerous. Below a depth of 12 inches the snail shells become less common and

fragments of shell more numerous. Even the fragments disappear almost entirely before a depth of 3 feet is reached. At this depth soft whitish lime specks are common, and a few hard lime particles or concretions are present. In some places the lower part of the 5-foot section contains much soft white lime material in large and small aggregates.

This soil occurs in association with other Raymondville soils along the course of the old Rio Grande channel which extends northward from Hidalgo County. It occurs also in isolated, somewhat depressed flat areas. Several fairly large areas were mapped, the most important of which is on the Travis ranch, west of Lyford, and in the north-central part of the county. Owing to the flat surface, the very heavy texture of both surface soil and subsoil, and the compactness of this soil, drainage is poor or almost entirely lacking.

When thoroughly dry, though hard, this soil seems to crumble readily to fairly small clods. When wet it becomes extremely sticky, plastic, and boggy, and even after the surface has dried the material is saturated with water and very sticky and plastic at a depth of 1 foot below the surface. Following saturation the soil dries out to a very hard mass which cracks severely and widely, breaking up into large, hard clods. However, owing to the high lime content, the clods readily break down on exposure to air and moisture. The stickiness and plasticity of this soil when wet render it extremely unfavorable for farming operations. If a rainy period occurs during the growing season crops suffer acutely from lack of cultivation and from weed growth, the weeds in many places crowding out the crop. The heaviest type of farming equipment is necessary on this soil.

The best moisture conditions are necessary for fair or good yields on this soil. Cotton, corn, and the grain sorghums yield best, though corn fires early if moisture is lacking. In normal seasons yields ranging from one-fourth to one-third bale of cotton to the acre, from 20 to 30 bushels of corn, and from $1\frac{1}{2}$ to 2 tons at each of two cuttings of sorghum for hay may be obtained. In exceptional seasons these yields are increased. The unfavorable physical condition of the soil and a comparatively high salt content unfit this soil for citrus trees.

Very little of this soil is under cultivation. It supports a rather sparse, somewhat stunted growth of mesquite trees, huisache, and retama, with considerable white grass, broom sedge, and, in the more open spaces, some buffalo grass and mesquite grass.

Raymondville clay, salty phase.—The principal area of the salty phase of Raymondville clay is about 2 miles southeast of Nopal ranch in a depression on which there are a number of intermittent lakes. The chief difference between typical Raymondville clay and this phase is that the pinkish-brown or buff-brown colors of the typical subsoil are absent, gray being the predominating color in all areas. Water stands over the salty soil much of the time following wet seasons.

The growth of sacahuista grass is indicative of the high salt content of this soil. Sufficient salt is generally present to preclude the use of the soil for agricultural purposes. Other growths on this soil are chiefly huisache and mesquite trees.

POINT ISABEL FINE SANDY LOAM

The surface soil of Point Isabel fine sandy loam consists of grayish or grayish-brown generally calcareous slightly loamy fine sand or fine sandy loam, varying from 10 to 15 inches in thickness. This layer is underlain by calcareous, friable, gray or slightly brownish-gray fine sandy clay or clay loam containing a varying quantity of specks and streaks of soft white limy material. This layer continues to a depth ranging from 3 to 5 feet, where it gives way to light-gray, yellowish-gray, or cream-colored, highly calcareous, friable fine sandy clay or clay loam. As a rule this layer contains thin layers and streaks of soft white limy material.

Owing to the fact that this material is wind deposited and is derived from material varying in texture from sand to clay the structure and texture of areas occurring in different locations may differ somewhat. Strata of fine sand or clay may occur.

The material composing this soil was derived from the salty soils of the marine plain and from the beds of salt-water lakes or *valle salados* on this plain. The high salt content of the soil has a tendency to flocculate the soil particles following long dry periods. In this loose fluffy condition the soil grains are easily picked up by the winds and transported in the prevailing direction of air movement. As this process continued the depressions deepened, and many of the old channels and lake beds occurring on the windward side of the dunes are now from 10 to 20 feet deep and contain water, generally salty. (Pl. 2, A.)

This soil occurs as mounds, hummocks, or narrow ridges on the marine plain, at elevations ranging from 10 to 20 feet or slightly more above the level of the plain. The relief is typically dunelike, with rather steep slopes on the windward and more gentle slopes on the leeward side. Most of the areas mapped are in the northern part of the marine plain, south of Redfish Bay. The areas of Point Isabel clay mapped farther south include some areas of Point Isabel fine sandy loam, but most of these are so small and so varied in texture that it was impossible to map any but the prevailing soil, which was the clay. Drainage is good or excessive.

Tests with the Wheatstone bridge show that the total content of water-soluble salts in this soil is high. Owing to the proximity of the Gulf, most of these salts are sodium chloride or salt. The sandy surface materials and strata are the least salty, and the heavier layers have a rather high salt content. All of this soil remains in its virgin condition, the vegetation varying with the amount of salt present in the surface soil and also, apparently, with the age of the material. On the older, higher mounds the vegetation consists mainly of mesquite, yucca, and chaparral, with some prickly pear in places, and buffalo, mesquite, Bermuda, and sandspur grasses. (Pl. 2, B.) The lower dunes with a higher salt content may support only a few scattered mesquite, very little yucca, no prickly pear, and a sparser growth of the prevailing grasses. *Sacahuista* grass may grow along the base of the mounds.

Some of the areas mapped under this classification are still in process of formation, as conditions favorable to soil movement are gradually adding material to their surface. Vegetation seems to hold the soil when it becomes stationary. A few areas of very high salt content are bare of vegetation.

This soil is valuable for pasture only, its high salt content, location^r and small extent precluding agricultural utilization.

Point Isabel fine sandy loam, high phase.—The high phase of Point Isabel fine sandy loam occurs in fairly large areas north and northwest of La Sal Vieja, in the northwestern part of the county. The soil is derived largely from material blown by the winds from the bed of the present salty lakes, following the drying out of the surface and the loosening of the soil particles by the flocculating action of a high salt content. Owing to its mode of deposition and to the fact that the lake bed consisted of fine sands and clays, the deposited material varies somewhat in the thickness and texture of the layers, but most of it is more or less sandy.

The typical surface soil consists of slightly grayish-brown, in many places calcareous, loamy fine sand or fine sandy loam from 5 to 12 inches thick. This layer is underlain by slightly dark grayish-brown calcareous friable fine sandy clay or clay loam, generally containing some soft and semihard white lime accretions. Below a depth varying from 18 to 30 inches is light brownish-gray, yellowish-gray, or cream-colored calcareous friable sandy clay or clay loam which varies in thickness from 4 to 12 inches. This layer is underlain by a grayish-brown or grayish-yellow layer of the same texture. Much white lime occurs in the last two layers, some of the aggregates measuring an inch in diameter. When slightly moist these aggregates crush readily, but they are hard when dry. Below a depth ranging from 36 to 48 inches is grayish-yellow or light grayish-yellow friable highly calcareous fine sandy clay or clay loam containing small and large aggregates of soft white lime and streaks of the same material. In some places the lower layer described has a distinctly pinkish cast. This material continues to a depth of 6 or more feet. Following continued dry weather the grayish tinge is accentuated, but when moist a brownish cast is assumed by the surface soil and subsoil.

Near the edge of La Sal Vieja the surface material is, in some places, fine sandy clay loam, and the subsoil material also is commonly slightly heavier in texture than typical.

Point Isabel fine sandy loam, high phase, occurs on the highest elevations in Willacy County, the mounds occupied by this soil rising from 10 to 35 feet above the surrounding plain. The surface is undulating or slightly hilly. Owing to the porosity of the soil and to the surface relief, drainage is good or almost excessive. During heavy rains the run-off is considerable on the more sloping areas. However, the soil absorbs water readily and retains moisture equally as well as Willacy fine sandy loam. With cultivation to destroy weed growth and to provide a mulch, moisture is present in this soil long after heavier soils become droughty. The organic-matter content is fair or good, and altogether this is regarded as a good, strong soil.

Virgin areas of this soil are covered with mesquite, some retama and ebony, prickly pear, mock olive, allthorn, cat's-claw, sweetshrub, and other plants. The grass growth is mainly buffalo and mesquite, with considerable sandspur.

When cultivated to the staple crops of the county the more level areas of this soil are considered as productive as Willacy fine sandy loam. A good moisture supply is necessary for obtaining good crop yields, but with conservation of a moderate moisture supply fair or good crops are obtained. With a favorable moisture supply the average cotton production ranges from one-half to three-fourths bale to the

acre, corn yields 40 bushels, and the sorghums produce two or three crops of hay, each cutting averaging from 1½ to 2½ tons to the acre. Citrus trees would do well on the better-drained areas if sufficient water could be procured to supplement the annual rainfall. The content of water-soluble salts in soil of this phase is low.

POINT ISABEL CLAY

Typical Point Isabel clay has a surface soil of gray or brownish-gray calcareous clay, ranging from 6 to 12 inches in thickness. This is underlain generally by clay loam or heavy clay loam of the same color, which grades, at a depth varying from 20 to 30 inches, into light grayish-brown or light brownish-gray clay in which the gray color predominates when the material is thoroughly dry. Below a depth of about 5 feet is yellowish-gray or yellowish-brown, in some places slightly pinkish-brown, highly calcareous fine sandy clay or clay loam containing much soft white limy material in large and small aggregates and thin layers and streaks. This layer continues downward to the basal material, which consists either of coastal beach material or material similar to that composing the Lomalto soils, on which the mounds, hummocks, or ridges of this material rest. In a few places there is not much change in the color and texture of the soil to a depth of 5 or more feet. The soil is calcareous from the surface downward. The heavy soil material is readily crumbled with the fingers after it has been dry for some time, but it is very sticky and plastic when wet.

The material composing this soil was deposited in its present position by winds, in the same manner as Point Isabel fine sandy loam. It has a typical dune configuration. Drainage is aided by the relief, and the run-off is large during heavy rains.

Owing to the texture of the material, which resists the downward movement of moisture to some extent, and to the fact that the fine-textured material in its original location had a higher salt content, this soil has a higher total content of water-soluble salts than the fine sandy loam member of the Point Isabel series, with which it is associated. This salt content and the age of the dunes affect the vegetation somewhat. In the surface material of the older, higher dunes less salt is present than on the lower, younger dunes. Considerable mesquite, some yucca, some chaparral, and a few prickly pears grow on the older dunes. The grasses consist mainly of buffalo grass, but some white grass and sacahuista grass may grow at the base of the mounds. In a few gray, barren areas the salt content was so high as to discourage the growth of all vegetation.

On account of its high salt content this soil is nonagricultural but it is valuable for grazing purposes. Since the dunes stand from 10 to 15 or more feet above the surrounding marine plain and are high and dry during wet seasons or when storms force the waters of the Laguna Madre over the marine plain, they form a favorite refuge for cattle pasturing on the marine plain.

TIOCANO CLAY

Tiocano clay consists of dark ash-gray, ash-black, or black clay, which may continue to a depth of more than 3 feet without change. Usually, however, at a depth varying from 8 to 30 inches it gives

way to dark-gray or gray heavy clay, which may become mottled with yellowish or brown at a depth of 4 or 5 feet. Both surface soil and subsoil are hard and tough when dry, cracking deeply and widely, and both are extremely plastic and sticky when wet. In the areas in the western part of the county lime is not generally present in this soil above a depth between 3 and 5 feet, but the large areas in the eastern part are generally calcareous from the surface downward.

In the vicinity of Paso Real three small areas included with this soil along Arroyo Colorado are mainly typical Harlingen clay, but they were mapped with Tiocano clay on account of their small total extent in Willacy County. These included areas consist of ash grayish-brown or dark ash-brown clay, which continues below the 3-foot depth without change. When moist the soil assumes a distinct brown color slightly darker in the surface few inches. These areas are generally calcareous from the surface downward. The vegetation is practically the same as that on typical Tiocano clay. The areas are low and are poorly drained.

Most of the Tiocano clay occurs as small depressions within Willacy fine sandy loam, Victoria fine sandy loam, or Victoria fine sandy clay loam areas, where it appears to be caused by wind action removing the original sandy cover. Elevated areas of sandy soils generally occur northwest of the depressions. In the northeastern and southeastern parts of the county there are several large typical areas, the surface of which is depressed from several inches to a foot below the surrounding territory. In rainy seasons water collects in these depressions and generally stands for some time, owing to the poor drainage afforded by the heavy texture of the soil. The small areas in the western part of the county have pothole characteristics, but though numerous, these areas were so small that many of them were not separated in mapping. In some localities several of these potholes, which hold water for long periods after rains, occur on a quarter section.

This soil is not utilized in crop production, but where the areas are not too heavily covered with brush or where water does not stand too long a growth of buffalo grass or Bermuda grass provides good pasturage. Mesquite and granjeno generally grow at the edges of the depressions, and huisache and retama are common in the more poorly drained places.

The presence of a small patch or two of this soil on lands desirable for farming is considered beneficial, since the depressions act as tanks to hold water for livestock for a considerable period after the dry season begins and also provide some pasturage. It is suggested that some of the depressions be cleared and experiments made around the higher rim with Para grass and Angleton grass, both of which are adapted to poorly drained soils.

LOMALTO FINE SANDY LOAM

To a depth varying from 10 to 24 inches Lomalto fine sandy loam consists of slightly brownish-gray or grayish-brown loose fine sand, which is slightly darker to a depth of one inch, owing to the presence of a little organic matter. As a rule this layer is very abruptly underlain by gray or slightly dark-gray sandy clay or clay, which soon becomes mottled with ochreous yellow and rust brown or

which may consist of ocherous-yellow and gray sandy clay. Below a depth varying from 36 to 60 inches there may be present any of the following materials: (1) Light-gray sandy clay or clay, mottled with yellow, ocherous yellow, or rust brown and continuing to a depth greater than 6 feet; (2) yellowish-gray, light-gray, or in some places grayish buff-brown calcareous sandy clay or clay loam containing soft white lime concretions and continuing below the 6-foot depth; or (3) where this soil grades into Lomalto clay loam, light grayish-brown or pinkish, usually highly calcareous clay loam containing some soft white lime concretions and snail shells or shell fragments. The first two materials are most common.

Lomalto fine sandy loam is mapped in fairly large areas extending back from the true marine plain toward the Nueces soils. It grades into Nueces fine sand, shallow salty phase, so imperceptibly and the soils are so similar that a separation between the two is purely arbitrary. This soil does not have the true marine-plain relief, since it is mainly gently undulating or nearly level, whereas the marine-plain soils are flat, broken only by slight depressions. This soil does not occur south of the area occupied by the Nueces soils.

Sacahuista grass, needle grass, sandspur, some goatweed, and an occasional bunch of prickly pear and mesquite constitute the vegetation on this soil. Most of the land is prairie and is utilized only as pasture. The surface of the soil drifts somewhat during heavy windstorms.

LOMALTO CLAY LOAM

The surface soil of Lomalto clay loam may be dark-gray, grayish-brown, or brown clay loam, varying from 8 to 15 inches in thickness. It is underlain by grayish-brown or light-brown clay loam or light clay which continues to a depth ranging from 20 to 30 inches, where it is underlain by yellowish-brown, brown, or buff-brown clay which may continue to a depth of more than 5 feet without change but which is commonly mottled or splotted with gray and ocherous yellow. The typical soil is usually calcareous from the surface down. The yellowish-brown, brown, or buff-brown layer is highly calcareous and in most places contains more or less soft white lime material. Fragments of snail shells are present to a depth of 2 feet, and the surface and upper part of the soil in some places are thickly strewn with them. Fiddler crabholes and chimneys are common in the lower areas. In the lower part of the soil salt aggregates are common, and gypsum crystals are present in some places. When the soil is dry salt crystals may be seen over the surface in many areas.

Some variations from typical occur, particularly in the upper part of the soil. In places gray or brown fine sandy loam several inches thick lies over the material described as the surface soil. In other places hummocks of gray fine sand from 12 to 18 inches thick occur over the typical surface material. As mapped this soil also includes small areas of the fine sandy clay loam and clay members of the Lomalto series. A few areas of Lomalto fine sandy clay loam, differing chiefly in texture, are included with mapped areas of this soil.

This soil occurs on the flat, poorly drained marine plain. During wet seasons it is saturated and water frequently covers the surface to a depth of several inches for long periods after rainy seasons.

Even following long dry periods salt water is reached at a depth of 2 feet in most places. The soil is generally associated with other members of the Lomalto series and grades westward into the salty phases of the soils of the alluvial plain.

The vegetation on this soil is a typical marine-plant growth, consisting mainly of sacahuista grass, sea orange, and sea purslane. The growth of the sacahuista grass is thicker in places where the salt content is lower, especially at the edge of the alluvial plain. Where the salt content of this soil is particularly high, the sacahuista grass is dwarfed and scant and other salt-loving plants dominate. A few areas in which the soil was so salty as to kill out all vegetation were seen.

This soil occurs in large areas in the eastern and southeastern parts of the county. It has little value for pasture, and its low position, undrained condition, and high salt content unfit it for any other agricultural purpose.

LOMALTO CLAY

The surface soil of Lomalto clay, to a depth varying from 6 to 10 inches, consists of dark-gray or dark brownish-gray clay which on drying assumes an ash color. This layer is underlain by gray or grayish-brown rather heavy clay, mottled in places with dark gray, yellowish, or yellowish brown, which extends to an average depth of about 20 inches. The third layer, which extends to a depth ranging from 40 to 60 inches, consists of yellowish-gray, light grayish-brown, or pinkish grayish-brown clay loam or clay. This material is highly calcareous and generally contains more or less soft white limy material and some snail shells and fragments. A fourth layer, which is not everywhere present above a depth of 5 feet or which may be entirely absent, consists of light-gray or yellowish-gray clay, mottled with gray and ocherous yellow. The soil is calcareous from the surface downward. Crystals of salt and gypsum are generally found in borings. Crabholes and chimneys are common in many places, and snail shells and fragments are numerous on the surface and in the upper part of the soil in many areas.

In slight depressions the soil commonly consists of dark-gray or nearly black clay, underlain by gray or light-gray clay, mottled in most places in its lower part with rust brown and ocherous yellow. A perpendicular cut through this soil may show a succession of changes from dark gray to light gray or gray, and ocherous-yellow and gray clay layers are common.

Included in mapped areas of this soil are small areas of a light-colored phase. This consists of ash grayish-brown or light grayish-brown clay, which becomes light brownish gray or brownish gray below a depth of 15 inches. Between depths of about 30 inches and more than 5 feet, this material becomes yellowish, pinkish grayish brown, or grayish buff brown. This included soil occurs mainly as small slightly elevated areas within typical Lomalto clay. It is calcareous from the surface downward and supports the same vegetation as the typical soil.

When dry the surface of Lomalto clay becomes very hard and cracks widely. When wet the material is very plastic, sticky, and boggy. Since the soil occurs on the practically flat marine plain,

water stands on the surface for long periods after rains, and even after prolonged dry seasons the salt-water table is usually reached at a depth of 1 or 2 feet.

This soil has a high salt content but not so high as Lomalto clay loam. The vegetation consists chiefly of tall and dwarfed sacahuista grass, sea orange, sea purslane, and a profusion of other salt-loving plants.

Lomalto clay occurs in large areas in the southeastern part of the county, mainly adjacent to the salty phase of Victoria clay loam. The darker color of this member of the Lomalto series is probably owing to the admixture of dark-colored alluvial material. Where this soil grades into the Victoria soils there is generally a scattered growth of mesquite and, in a few places, a heavy growth of buffalo grass.

LOMALTO AND NUECES SOILS, UNDIFFERENTIATED

The Lomalto and Nueces soils, undifferentiated, include an intricate mixture of areas of Lomalto fine sandy loam, Lomalto fine sandy clay loam, Lomalto clay loam, dune sand, Nueces fine sand, and Nueces fine sand, shallow phase.

Between Tenerias ranch and Redfish Bay is an area in which there has been and still is considerable movement of soil material by the winds. The original material which gave rise to the present Nueces fine sand and dune sand was shifted to an area on the marine plain. During the progress of the original deposition of the sandy material by the wind, during the subsequent reworkings, and in the present movements of the loose material by the prevailing southeasterly winds, there have been left between the dunes a number of troughs, with axes in the same general direction as the dunes. Some areas of the original marine plain were denuded of their sandy material, possibly because there was no vegetation to hold the sand. Some of the original marine-plain material has been removed by the wind, after flocculation of the soil particles, caused by the high salts content, had taken place. The material removed was mixed with the sandy material as is evidenced by thin layers of slightly cemented sands present in the dunes. In the troughs and the areas first uncovered there are miniature dunes, which are constantly shifted about and added to by the swirling air currents which drop into the depressions. The wind is also constantly moving the sand into the southeastern extremity of the pits, removing it from the northwestern end.

This movement by the wind has caused depressions to form between areas of dune sand and Nueces fine sand, in which occur small moving dunes, small areas of Nueces fine sand and its shallow phase (which differ from the moving dunes only in that they are covered with vegetation) and, between these sandy areas, small spots and streaks of the Lomalto soils and depressions within the Lomalto soils which are filled with water much of the time. During the wet seasons most of the depressions between the dunes and Nueces fine sand are filled with water, so that only the small dunes and areas of Nueces fine sand are visible.

Sacahuista grass grows on the areas of Lomalto soils and some sand-spur and needle grass are seen on the Nueces soils, but the dunes are barren. Areas of these mixed soils are of value only for the slight

pasturage they afford and as reservoirs for water. However, following long dry seasons, the water becomes scarce and brackish because of the high salt content of the underlying marine material.

LAREDO SILT LOAM

Only a small total area of Laredo silt loam was mapped, and this is in the vicinity of Paso Real, from which place it extends eastward along the Arroyo Colorado. The soil occupies a natural levee position along the north bank of the stream and is subject to overflow only by the highest waters. The higher part of the levee stands about 5 feet above the level of the surrounding country.

The surface soil of dry Laredo silt loam consists of light grayish-brown silt loam, which contains considerable very fine sand in places and which continues to a depth ranging from 8 to 12 inches. This layer is underlain by grayish-brown or ash grayish-brown silty clay loam or clay loam which extends to a depth of about 30 inches. This second layer may contain strata of fine sand or very fine sand a few inches thick, or may be separated from the first layer by a sandy stratum. Below a depth of about 30 inches there is generally yellowish-brown or slightly pinkish or buff-brown fine sandy loam or very fine sandy loam, which at a depth of about 5 or 6 feet grades into grayish-brown or dark grayish-brown clay. When moist all layers except the lowest have a more or less yellowish-brown appearance. The soil is calcareous from the surface downward.

The natural levee occupied by Laredo silt loam was built up by the Arroyo Colorado during times of overflow. It slopes gently away from the stream. Drainage is good, owing to the slight slope and the porosity of both surface soil and subsoil. When wet the soil is rather sticky, but it soon dries out. The organic-matter content is fair or good.

In its virgin condition this soil supports a rather heavy growth of mesquite, brazil, and ebony, with some retama and huisache, and a rather heavy undergrowth of prickly pear, chaparral, Texas whiteleaf, and sweetshrub. The grass growth consists of buffalo and Bermuda grasses, with some sandspur. In cultivated fields crabgrass is rather thick.

This soil is very friable and is easily reduced to and maintained in good tilth. Perhaps half the total area is under cultivation. Cotton and corn are the chief crops grown, and during the 1926 season good yields of these crops were obtained. The land is suited to most of the staple and special crops grown in this county. Crop yields depend on the supply and favorable distribution of moisture.

NUECES FINE SAND

The surface soil of Nueces fine sand, to a depth varying from 9 to 15 inches, consists of brownish-gray or grayish-brown loose fine sand containing a comparatively small quantity of organic matter. This is underlain by light grayish-brown, grayish-yellow, or pale-yellow fine sand several feet thick, which is also loose. When moist the soils are darker brown in color. Below the 3-foot depth is heavy bluish-gray clay, mottled with yellow and here and there with red. This clay becomes hard when dry and plastic and sticky when water-soaked. Below a depth varying from 5 to 8 feet is cream-colored or

buff-brown calcareous clay which contains considerable soft whitish limy material. This calcareous material extends to undetermined depths. No caliche layer, such as is found under the surface soil in central and western Hidalgo County, was observed in Willacy County. Neither the surface soil nor the subsoil is calcareous, and in places a neutral or faintly acid reaction was observed when soiltex was applied to the surface soil.

Areas of typical Nueces fine sand in Willacy County are more or less densely covered with mesquite, but there is very little other tree growth. Some prickly pear occurs here and there. Foxtail and needle grass form the principal grass growth, and in the flatter areas broom sedge is common.

Rather large areas of this soil have smooth surfaces, some areas have hummocky or gently undulating surfaces, and others have an alternating dune and valley configuration. Wind action has figured largely in the contour of the surface soil. In many areas small mounds occur around the bases of mesquite trees, and even where there is a light growth of grass the material shifts somewhat when dry. Where the surface soil is broken by overpasturing or other causes, the wind immediately begins to move the surface material and gradually increases the area and depth from which the sand is removed, scoops out large basins, and builds up dunes of considerable size. This loose moving material is included with dune sand in mapping. The more dunelike areas of Nueces fine sand are in the northeastern part of the county.

Drainage of this soil is accomplished only through the open structure of the soil. Where depressions occur and the heavy subsoil lies at a slight depth, ponds of water accumulate during the wet season. A few permanent and many intermittent fresh-water lakes occur on this soil. These depressions serve as reservoirs for artesian-well water.

Only small areas of this soil are cultivated, and in most of these the subsoil lies near the 3-foot depth and the organic-matter content is above normal. The crops grown are cotton, corn, sweet potatoes, and watermelons. The best yields are obtained when good rains fall during the winter and early spring months. Under proper cultural methods the land retains moisture well. In exceptionally dry years all crops are apt to fail or to produce very low yields. Some small dunelike areas near the Kenedy County line are used mainly for pastures. These support a tree growth of scrub live oak and a sparse grass growth.

In seasons of best moisture distribution the soil may yield an average of as much as one-fourth bale of cotton to the acre and from 15 to 20 bushels of corn, without fertilization. Watermelons yield from one-half to 1 carload of marketable melons to the acre, the best yields being obtained under fertilization with a 2-8-2 mixture.

During exceptionally dry seasons winds may shift sand and cut the young growing crops or may remove the sand from around the plants.

The price of land of this kind varies from \$8 to slightly more than \$15 an acre, depending mainly on location, improvements, and other features.

Nueces fine sand, prairie phase.—In the northeastern part of the county are areas of Nueces fine sand material which differ from

the typical soil in that the heavy subsoil does not occur within the 6-foot depth. These areas occur under prairie conditions and support the same grass growth as that on typical Nueces fine sand. The surface varies from gently undulating to rolling or dunelike. The porosity of the soil renders drainage good or excessive.

Soil of the prairie phase has the appearance of recent wind-transported material over most of which only a grass cover has developed. In a few places scattered clumps of small mesquite and live oak were seen.

This land has no value except for pasture, and care must be taken to pasture very lightly in order to prevent destruction of the grass cover.

Nueces fine sand, shallow phase.—The surface soil of the shallow phase of Nueces fine sand, to a depth varying from 9 to 15 inches, consists of brownish-gray or grayish-brown loose fine sand containing a low average quantity of organic matter. This layer is underlain by light grayish-brown, grayish-yellow, or pale-yellow incoherent fine sand which continues to a depth ranging from 20 to 36 inches, where heavy bluish-gray clay mottled with yellow and in some places with red, occurs. This heavy clay continues to a depth of 5 or 6 feet, where it is generally underlain by yellowish-brown or buff-brown calcareous clay containing white soft lime aggregates of various sizes. In the western part of the county the depth to this material is greater. No caliche was found under this soil, but in some places a slightly acid reaction was given by the surface soil.

The tree and grass growth is the same as that on typical Nueces fine sand, but the mesquite growth is probably a little thicker and larger and the grass growth, especially of broom sedge, is slightly heavier. In the vicinity of Tenerias ranch, in the northeastern part of the county, several areas of Nueces fine sand, shallow phase, have only a grass cover. These areas are smooth or gently undulating, and drainage is good or excessive. The heavy subsoil material lies within 3 feet of the surface and the soil is not so easily saturated with water as other areas of the shallow phase where the subsoil is closer to the surface. Here the grass cover is slightly heavier than that on the typical Nueces soils, and the areas are used for pasture land.

Most of this soil is level or nearly level, but some small depressions and small billowy areas occur. On the mounds the subsoil may not occur within 3 feet of the surface, and areas in which the subsoil lies below this depth are mapped as typical Nueces fine sand. During rainy seasons water stands in the depressions, as the shallow heavy subsoil retards the downward movement of water. When the surface soil is thoroughly saturated, the subsoil becomes very plastic. When dry the subsoil becomes very hard, and the surface sands are readily shifted by the wind, except where the grass cover is heaviest. However, in uncultivated areas, this soil does not drift so readily as does Nueces fine sand.

Less than 1 per cent of this soil is under cultivation. It is easily handled when moderately moist or dry, and where properly cultivated retains moisture well. The chief crops grown are cotton, corn, sweet potatoes, and watermelons. A plentiful supply of moisture

during the winter and well-distributed rainfall during the spring are essential for best yields. Under the best conditions averages of one-fourth bale of cotton to the acre, between 15 and 20 or slightly more bushels of corn, and between one-half and 1 carload of marketable watermelons may be obtained. Blackberries, dewberries, and mus-tang grapes grow well on this soil. Yields of these fruits might be increased through the application of moderate quantities of fertilizer. Watermelons respond both in quality and quantity to applications of 100 pounds to the acre of a 2-8-2 fertilizer mixture.

Land of the shallow phase of Nueces fine sand is held at prices ranging from \$8 to \$15 an acre, depending on location, improvements, and other features.

Nueces fine sand, shallow salty phase.—The surface layer of this soil consists of grayish-brown or brownish-gray fine sand varying from 12 to 20 inches in thickness. The sand is only slightly coherent in the lower flatter areas but is loose over most of the soil. This layer is rather abruptly underlain by gray or slightly dark-gray clay, which contains a small quantity of sand. On penetrating the clay layer to a depth varying from 8 to 12 inches yellowish, ocherous-yellow, brown, or rust-brown mottles are found. Below a depth ranging from 36 to 50 inches light-gray, gray, or brownish-gray highly calcareous clay may occur. Much of this is mottled yellow or yellowish brown, and it may have a pinkish tinge. In a few areas this lower subsoil material was distinctly grayish buff brown. Lime concretions are generally present in this calcareous layer, which continues to a depth of more than 6 feet. In places where the calcareous layer is lacking, gray or dark-gray clay mottled with ocherous yellow and brown continues to a depth of more than 6 feet.

To a depth of 1 foot this soil has a rather low content of water-soluble salts, but in the subsoil a very high content is present. Sacahuista grass is a more or less common growth on this soil, and this indicates a salty condition. Needle grass, sandspur, goatweed, some Bermuda grass, and scattered clumps of small mesquite trees constitute the principal vegetation. A few prickly pears were seen. Most of this land is gently undulating and drainage is good or excessive, though it is retarded somewhat by the heavy subsoil.

Soil of this phase is mapped in the northeastern part of the county and represents a gradation from the deep sandy Nueces soils on the north and west to soils of the salty alluvial and marine plains. The land is nonagricultural and is used only for pasture. Where the vegetation is sparse, the surface soil drifts to some extent.

DUNE SAND

The material mapped as dune sand occurs on Padre Island and in the area in the northeastern part of the county where there is no vegetation and the material is still being moved about by the wind. In both places the areas have a typical dunelike relief, the southeastern or windward slope being fairly sharp and the northwestern or leeward slope being more gentle. These dunes stand from 10 to 25 or more feet above the surrounding land. Their axes extend from southeast to northwest, the direction of the prevailing winds. On the mainland the dunes are associated with the Nueces soils, and the

depressions occurring in troughs along their axes and between the dunes are composed of material described as Lomalto and Nueces soils, undifferentiated.

The material composing the dunes consists of yellowish-gray or brownish-gray fine sand, which is almost devoid of organic matter. This extends without change from the surface of the dunes to the level of the marine plain. Areas of like material which have become stabilized under a grass covering are mapped as Nueces fine sand. On some areas of Nueces fine sand the grass covering has been removed by overgrazing or by the dying of the vegetation following droughts, and the material has again assumed its original dune-sand character. Dune sand occupies a fairly large area in Willacy County.

COASTAL BEACH

Coastal beach includes narrow strips of material between the Laguna Madre and soils of the Lomalto series, in the vicinity of Redfish Bay. The material consists mainly of grayish-brown fine sand and medium sand, with which are mixed large quantities of shells and minute shell fragments. This material may continue to a depth of 4 or 5 feet, or it may be interstratified with clay loam and clay ranging from gray to brown or black in color.

Since areas of coastal beach lie practically at sea level they may be covered with water when strong winds force the waters of the laguna westward. The areas are devoid of vegetation.

ALKALI

Alkali salts occurring in the soils of Willacy County come from two sources. The first, which affects all the soils of the county, is the chemical activity within the soils which gives rise to these alkali and other salts. The second is the incorporation of alkali salts within the soil mass, owing to the deposition of alluvial material in the salt water of the sea and during the process of reworking of marine and alluvial sediments by sea water.

The principal salts known as alkali in Willacy County are sodium chloride, sodium bicarbonate, and sodium sulphate (*1, p. 1106-1107*). Others are the chlorides, sulphates, and bicarbonates of potassium, calcium, and magnesium. These belong to the white-alkali group. Sodium carbonate, known also as black alkali, is not shown to be present by analyses of soils from the lower Rio Grande Valley.

The soil particles brought into their present position through alluvial and fluvial agencies were developed under an annual rainfall varying from less than 15 to 20 inches. In their present position they are subject to an annual rainfall ranging from 22 to 29 inches. Under such low rainfall the soils are not subject to so much leaching as soils in areas of higher rainfall. Therefore the alkali salts retained by the sedimentary material, even after deposition, plus those developed since the time of deposition, have not been entirely leached from the soil. In those areas where drainage was better, either because of the relief or of the greater openness of the soil, leaching has been very active. In flat or heavy-textured areas where drainage is retarded leaching is reduced to a minimum and the content of alkali is great.

The presence of a salt-water stratum affects the lower part of much of the soil in Willacy County, particularly east of Lasara. In the vicinity of the main line of the railroad this salt-water stratum lies at a depth ranging from 12 to 20 feet. The depth becomes slighter eastward. About 12 miles east of Raymondville it occurs at a depth ranging from 8 to 15 feet. Judging from the results of tests of the fifth foot of soil in some of the lower areas, this soil has proved to be affected by this salt-water stratum, either through capillarity or otherwise. However, over most of this area no harmful effect is noted at the 5-foot depth.

The alkali salts, if present in sufficient amounts, are toxic to the growth of various plants and result in the killing of those plants which are least resistant and in a stunted growth to those which have some resistance. Other plants apparently do better where a high content of salt exists. Experience in the irrigated section of the lower Rio Grande delta shows that citrus trees are affected by a water-soluble salts content of more than 0.1 per cent, and they become dwarfed or die when the total alkali content of the soil reaches 0.165 per cent. Where the content ranges between the latter figure and 0.2 per cent the germination of cotton is affected, and even though the plant starts to grow it may die on reaching a height of 3 or 4 inches. The staple farm crops and vegetable crops grown in this section do not seem to be affected by a salts content of less than 0.165 or 0.2 per cent. Mesquite trees grow on soils containing about 0.15 per cent, but where the content of the surface soil to a depth of 1 foot is more than this the growth becomes dwarfed and scattered. Buffalo grass does not seem to be affected by as much as 0.25 per cent, and Bermuda grass thrives on areas containing an equally high percentage where the moisture content is sufficient. Sacahuista grass prefers soils containing a high salt content and grows on soils containing from 0.15 to nearly 1 per cent of salts, chiefly sodium chloride. Where more than 0.5 per cent is present, however, the growth is dwarfed and scattered. Sea orange, sea purslane, and other salt-loving plants grow on soils containing as high as 1.5 or 2 per cent of salt. When the salt content is more than this, the soil is either barren or sustains only a very small scattered growth.

Nearly 100 studies of the 5-foot profile of soils in various parts of Willacy County were made during the course of the survey. Sufficient tests were made to secure the range of alkali content of the various soil types and phases mapped. Separate tests were made of each foot of soil down to and including the fifth foot. The location of these tests is shown on the map, and the results are indicated by means of a fraction, thus: $\frac{8.11}{42}$. The numerator indicates the percentage of water-soluble salts in the surface foot of soil, and the denominator indicates the average content found in the 5-foot section.

Table 3 shows the average total water-soluble salts content of the principal soil types and phases in Willacy County, the average content of each foot being shown and the average content of all 5-foot sections of each soil type or phase.

TABLE 3.—Average content of water-soluble salts in the principal soils in Willacy County, Tex.

Soil type	First foot	Second foot	Third foot	Fourth foot	Fifth foot	Average
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
Victoria fine sandy loam	0.056	0.063	0.057	0.062	0.071	0.062
Victoria fine sandy loam, salty phase	.203	.347	.400	.413	.437	.360
Victoria fine sandy clay loam	.061	.065	.087	.101	.115	.086
Victoria fine sandy clay loam, salt affected	.123	.168	.180	.180	.189	.168
Victoria clay loam	.051	.053	.065	.077	.089	.067
Victoria clay loam, salt affected	.353	.474	.566	.539	.685	.624
Victoria clay loam, salty phase	.430	.543	.589	.886	.092	.670
Victoria fine sandy clay loam, light-colored phase	.033	.046	.067	.079	.079	.060
Victoria clay loam, light-colored phase	.066	.065	.071	.069	.083	.072
Victoria clay loam, light-colored phase, salt affected	.084	.089	.090	.318	.553	.223
Raymondville fine sandy clay loam	.055	.069	.063	.076	.091	.069
Raymondville fine sandy clay loam, salt affected	.035	.070	.162	.230	.350	.171
Raymondville fine sandy clay loam, salty phase	.690	1.040	1.040	1.320	1.320	1.080
Raymondville clay loam	.064	.083	.096	.096	.112	.090
Raymondville clay	.045	.045	.111	.171	.176	.112
Willacy fine sandy loam	.050	.060	.071	.082	.084	.069
Willacy fine sandy loam, salt affected	.039	.088	.200	.394	.424	.229
Willacy fine sandy loam, salty phase	.361	.787	.778	.694	.784	.629
Willacy fine sandy loam, flat phase	.041	.151	.223	.263	.282	.192
Point Isabel fine sandy loam	.146	.212	.271	.390	.452	.294
Point Isabel fine sandy loam, high phase	.040	.033	.030	.033	.033	.034
Laredo silt loam	.034	.034	.105	.066	.033	.055
Nueces fine sand, shallow phase	.008	.027	.059	.084	.115	.059
Nueces fine sand, shallow salty phase	.044	.102	.224	.366	.384	.224
Lomalto fine sandy loam	.078	.178	.271	.377	.478	.276
Lomalto fine sandy clay loam (included in mapped areas of Lomalto clay loam)	.228	.225	.256	.268	.273	.250
Lomalto clay	.180	.198	.207	.215	.205	.201
Lomalto clay loam	.798	.933	.998	1.060	1.260	1.010

Salty phases of most of the soils in Willacy County were mapped. The extent of these salty phases was determined by the presence or absence of sacahuista grass and other salt-loving vegetation. The tests for total content of water-soluble salts, which were conducted in the field by means of the Wheatstone bridge for determination of soil alkali through the electrical resistance method, bore out the common theory that sacahuista grass is a positive means of identification of soils high in content of sodium chloride or common salt. Where this grass grows, there is generally a content of salt in excess of 0.15 per cent. However, on some areas having an excess of or nearly this amount sacahuista grass had not yet taken hold. These areas were chiefly west of the main areas supporting sacahuista grass. Therefore, if it had been possible to make a thorough Wheatstone-bridge test of all soils in the county during the process of mapping, the salty phases would have been mapped somewhat farther westward.

It was also found that west of the salty phases mapped on the basis of the presence or absence of sacahuista grass is a belt, from one-half to 3 or more miles in width in places, in which the surface soil to a depth of a foot or two appears to contain a low total content of water-soluble salts, but the second or third foot to have a very high content. This is owing no doubt to the influence of salt water on the lower soil layers, the sediments composing these layers probably having been deposited in salt water before the alluvial material pushed the waters of the Gulf out to their present location, whereas the material of the upper layers was deposited over the salt-water layers or above salt-water influence.

Owing to the presence of a high content of water-soluble salts in all except the upper foot or so of the soil, which was not indicated

by vegetable growth, there is shown in Tables 3 and 4 a classification of salt-affected soils. Such areas are not, however, indicated on the soil map. Generally speaking, this area of salt-affected soils extends westward from areas of the salty phases of the various soils mapped to a point near Paso Real, thence northwestward to El Laurel ranch and a point about 2 miles west of El Sauz ranch, northward about 2 miles, northwestward to a point several miles northwest of San Andreas ranch, thence eastward to Tenerias ranch, where the line joins the salty phases.

The toxicity of the alkali salts in the surface foot or two of the soils in this county is rarely sufficient to be harmful to crops, particularly in the western part of the area just described and on the higher-lying fine sandy loam soils, yet the content of water-soluble salts in the lower part of the 5-foot layer ranges from high to very high. The high content apparently begins slightly nearer the surface in the Willacy and Victoria fine sandy loams than in the other soils. Under dry-farming conditions this high salt content may never affect the average field crops but might affect citrus trees and deep-rooted trees and crops. Under irrigation, however, the tendency is for these salts to rise, with consequent damage to crops of low toxic resistance.

Table 4 shows the range in the content of water-soluble salts in the principal soils of Willacy County.

TABLE 4.—Range of content of water-soluble salts in the principal soils in Willacy County, Tex.

Soil type	First foot	Second foot	Third foot	Fourth foot	Fifth foot	Average
	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>	<i>Per cent</i>
Victoria fine sandy loam.....	0.048-0.069	0.048-0.079	0.043-0.082	0.057-0.079	0.056-0.079	0.051-0.078
Victoria fine sandy loam, salty phase.....	.055-.310	.172-.390	.370-.438	.390-.446	.402-.470	.303-.398
Victoria fine sandy clay loam.....	.056-.066	.060-.069	.062-.137	.063-.156	.075-.163	.066-.116
Victoria fine sandy clay loam, salt affected.....	.090-.155	.166-.170	.180	.180	.185-.193	.163-.173
Victoria clay loam.....	.035-.072	.033-.076	.036-.090	.043-.123	.045-.156	.039-.101
Victoria clay loam, salt affected.....	.120-.680	.172-.812	.172-.936	.172-.936	.175-1.02	.162-.877
Victoria clay loam, salty phase.....	.197-.700	.200-1.23	.197-1.32	.197-1.48	.197-1.53	.198-1.25
Victoria fine sandy clay loam, light-colored phase.....	.033	.046	.057	.079	.079	.060
Victoria clay loam, light-colored phase.....	.050-.082	.051-.079	.060-.082	.064-.074	.074-.091	.060-.083
Victoria clay loam, light-colored phase, salt affected.....	.064	.086	.090	.318	.558	.223
Raymondville fine sandy clay loam.....	.040-.056	.045-.063	.055-.078	.066-.082	.066-.126	.055-.081
Raymondville fine sandy clay loam, salty phase.....	.690	1.04	1.04	1.32	1.32	1.08
Raymondville fine sandy clay loam, salt affected.....	.035	.079	.162	.230	.350	.171
Raymondville clay loam.....	.061-.066	.050-.137	.045-.160	.048-.166	.059-.166	.054-.138
Raymondville clay.....	.045	.057	.111	.171	.176	.112
Willacy fine sandy loam.....	.030-.065	.030-.082	.017-.116	.025-.146	.023-.157	.025-.113
Willacy fine sandy loam, salt affected.....	.035-.042	.082-.093	.200	.360-.428	.420-.428	.222-.236
Willacy fine sandy loam, salty phase.....	.064-1.14	.155-1.94	.162-1.66	.175-1.32	.175-1.56	.146-1.52
Willacy fine sandy loam, flat phase.....	.034-.054	.076-.240	.076-.414	.112-.498	.135-.528	.091-.342
Point Isabel fine sandy loam.....	.115-.166	.153-.250	.160-.528	.160-.722	.185-1.04	.155-.463
Point Isabel fine sandy loam, high phase.....	.040	.033	.030	.033	.033	.034
Laredo silt loam.....	.034	.034	.105	.066	.033	.055
Nueces fine sand, shallow phase.....	.008	.027	.059	.084	.115	.059
Nueces fine sand, shallow salty phase.....	.040-.047	.079-.124	.177-.270	.270-.462	.330-.438	.188-.260
Lomalto fine sandy loam.....	.057-.116	.076-.300	.101-.566	.146-.630	.266-.742	.129-.471
Lomalto fine sandy clay loam, included in mapped areas of Lomalto clay loam.....	1.75-3.50	1.58-3.50	1.70-4.00	1.94-4.00	1.94-4.00	1.81-3.80
Lomalto clay loam.....	.300-1.18	.370-1.32	.670-1.37	.890-1.58	.860-1.95	.630-1.44
Lomalto clay.....	.166-.193	.186-.210	.193-.220	.210-.220	.200-.210	.193-.209

Examination of Tables 3 and 4 shows that the typical well-drained soils of the Victoria, Raymondville, Willacy, and Nueces series have a low content of toxic salts throughout to a depth of 5 feet. They rarely contain sufficient alkali to injuriously affect citrus trees and the staple and special crops grown in the county at this time. The flat phase of Willacy fine sandy loam and the lower part of the heavier Raymondville soils have the highest content of water-soluble salts of soils west of the salt-affected zone. Some of the salt-affected phases show a higher average content than the salt phases, in spite of the fact that to a depth of a foot or two the salt content is low. This indicates a very heavy concentration in the lower part of the soil examined. In a few places the salty phases, mainly of the lighter-textured soils, showed a comparatively low content in the first foot. The Lomalto soils of the marine plain show a very high salt content, one area bare of all vegetation showing a content of 3.25 per cent each of total water-soluble salts in the upper 2 feet and 4 per cent each in the lower 3 feet. Although the Point Isabel soils are as a rule formed by wind deposition of very salty material, this deposition was sufficiently gradual to allow the leaching out of most of the alkali, particularly in the fine sandy loam, and a test on the high phase of this soil in the western part of the county shows a very low content throughout the 5-foot section. In the coastal areas of Point Isabel soils the content varies considerably, the fine sandy loam layers being much lower in total salt content than the clay layers. The presence of mesquite trees, yucca, Bermuda grass, and buffalo grass on the mounds occupied by Point Isabel fine sandy loam are vegetal indications of a comparatively low content of water-soluble salts in the upper layers.

The results of the test in the normal soils indicate a comparatively low content in all of the county west of the zone in which the alluvial material was deposited in or affected by salt water. It also shows, as a whole, a progressive increase in total salts content in soils of the same series with the increase in the amount of fine soil particles in the soil type; that is, the fine sandy clay loams of the same series have a higher total content of water-soluble salts than the fine sandy loams, and the clay loams a higher content than the fine sandy clay loams. The normal soils also show a progressive increase in salts content with depth. A discussion on the effect on the soils of irrigation and the application of excessive amounts of irrigation water and poor drainage and seepage in Hidalgo County is applicable to conditions in Willacy County, as most of the soils in the counties are similar.⁴

SUMMARY

Willacy County is situated in the extreme southern tip of Texas and is only one county removed from the Rio Grande, which separates the United States from Mexico. The county is included in the area generally referred to as the lower Rio Grande delta. On the broad, smooth plain occupied by the county there are four features of relief: (1) Two salt lakes in the western part of the county; (2) the numerous bays and inlets extending inland from the Laguna

⁴HAWKER, H. W., BECK, M. W., and DEVEREUX, R. E. SOIL SURVEY OF HIDALGO COUNTY, TEX. U. S. Dept. Agr., Bur. Chem. and Soils, Soil Survey Ser. 1925. [Unpublished manuscript.]

Madre; (3) a series of clay dunes and sand dunes, the material of which has been removed from the salty marine plain and the bottom of the salt-water bays and inlets owing to flocculation of the soil particles and their removal and deposition by wind in dune formation on the leeward side of the depressions; and (4) the large sand-dune area in the northern part of the county and on Padre Island. The relief varies from hilly and dunelike to flat.

Four major physiographic divisions are, in the main, coexistent with the major soil divisions. These are a comparatively high fluvial plain in the western part of the county, an alluvial plain in the central part, a marine plain in the eastern part, and an area of very sandy soils and sand dunes across the northern part and on Padre Island.

The elevation of the county varies from a few feet at the edge of the Laguna Madre to 75 feet above sea level.

The population of Willacy County in 1926 was estimated at 6,000, about 40 per cent of which is Mexican. Many new settlers are coming into the county at this time.

The climate of Willacy County is semitropical and semihumid. The county lies less than 200 miles north of the Torrid Zone, and the ninety-eighth meridian passes through the western part. There is an apparent decrease in precipitation westward across the county and an increase toward the coast.

The early agricultural pursuits in Willacy County consisted of cattle raising and the growing of subsistence crops for the ranchers. After the advent of the railroad, about 1904, the ranches were divided and sold to people from the North and East. It is estimated that 90,000 acres, at least half of which is planted to cotton, are in cultivation at the present time (1926). Cotton, corn, the sorghums, Sudan grass, and Rhodes grass are the principal staple crops, and onions, tomatoes, peppers, watermelons, and snap beans are the principal special crops. A few potatoes and sweet potatoes are also grown. Supplies of dairy and poultry products are generally insufficient for home needs.

The materials composing the soils of the county are geologically recent. Wind and water are the active agencies in their deposition.

The soils of the higher-lying terracelike fluvial plain are grouped in the Willacy series, of which the fine sandy loam is the most important soil. The alluvial soils are grouped in the Victoria, Raymondville, and Laredo series. On this plain the clay loam soils predominate. The soils of the marine plain are grouped in the Lomalto series. These soils are very high in salt content. The soils of the sandy area are grouped in the Nueces series and dune sand. The material removed by the wind from the salty lake beds and Lomalto soils was mapped in the Point Isabel series. Small depressions in the fluvial and alluvial plains were mapped as Tiocano soils. The miscellaneous designation, coastal beach, includes an intermixture of sand, clay, and shell fragments along the shore of the Laguna Madre.

Tests with the Wheatstone bridge to determine the content of water-soluble salts in the soils of the county show a comparatively low content in the soils of the fluvial or alluvial plains, and in the northern sandy area. The marine plain is very high in content of water-soluble salts which, on account of the proximity of the Gulf, consist mainly of sodium chloride or common salt. At the eastern

edge of the fluvial plain salt phases of the various soils were mapped, to differentiate the area in which the salt content was sufficient to be toxic to the agricultural plants grown in Willacy County. A zone of salt-affected soils, in which the lower part only was affected by a high salt content, occurs westward from the areas of salty phases.

The principal water-soluble salts found in this general region are the chlorides, sulphates, and bicarbonates of sodium, potassium, calcium, and magnesium, or the white alkali group. Black alkali is not present.

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[PUBLIC RESOLUTION—No. 9]

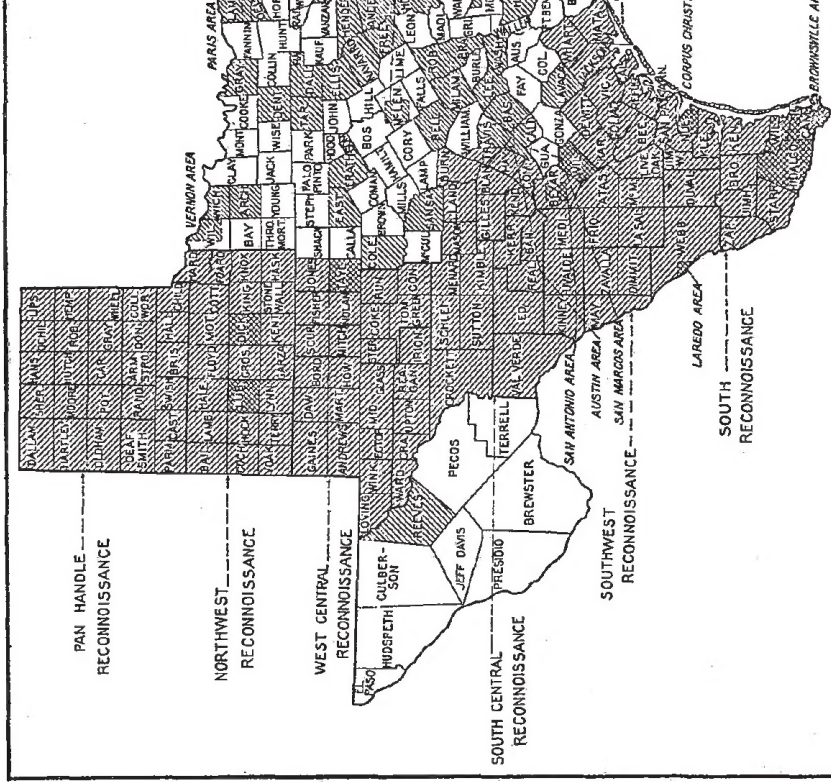
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided, That* in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Texas, shown by shading

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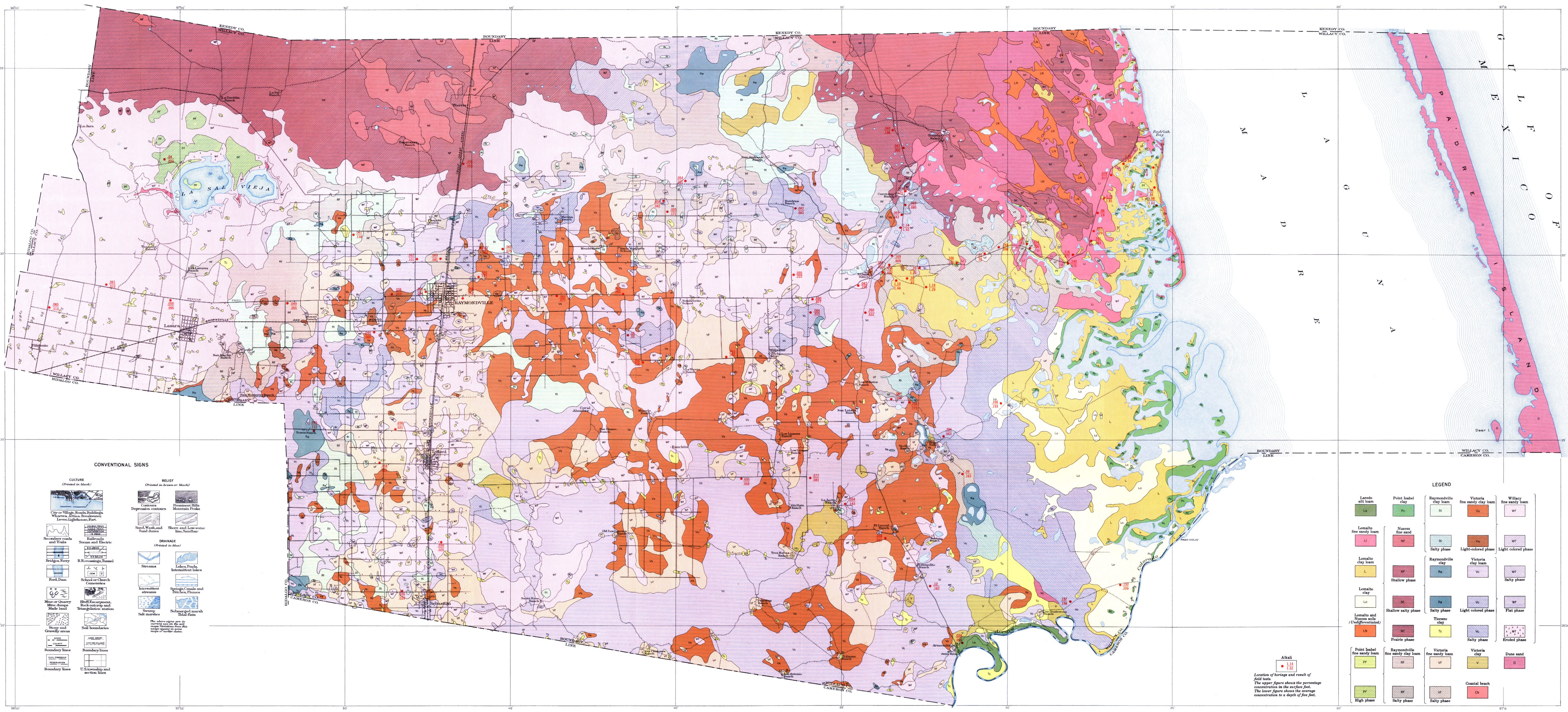
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- CULTURE**
(Printed in black)
- City or Village, Roads, Buildings, Wharves, Office, Dockhouse, Levees, Lighthouses, Fort.
 - Secondary roads and trails
 - Bridges, Ferry
 - Railroad
 - R.R. crossing, Tunnel
 - School or Church
 - Cemetery
 - Bluff, Escarpment, Rock outcrop and Transgression station
 - Shore and Low-water line, Sandbar
 - Swamp
 - Salt marshes
 - Soil boundaries
 - County
 - Boundary lines
 - U.S. township and section lines
- RELIEF**
(Printed in brown or black)
- Contours
 - Depression contours
 - Sand, Wash, and Sand dunes
 - Prominent Hills
 - Mountain Peaks
- DRAINAGE**
(Printed in blue)
- Streams
 - Lakes, Ponds, Intermittent lakes
 - Intermittent streams
 - Springs, Cauds and Ditches, Flumes
 - Subaqueous marsh
 - Field ditches
- The above signs are to be used in the soil maps. Variations from these signs are shown in some maps of earlier dates.*

LEGEND

- | | | | | |
|--|------------------------------|-------------------------------|-------------------------------|-------------------------|
| Laredo silt loam | Point Isabel clay | Raymondville clay loam | Victoria fine sandy clay loam | Willacy fine sandy loam |
| Ls | Pc | Ri | Vs | Wf |
| Lomalo fine sandy loam | Nueces fine sand | Salty phase | Light-colored phase | Light colored phase |
| Li | Nf | R | V | W |
| Lomalo clay loam | Shallow phase | Raymondville clay | Victoria clay loam | Salty phase |
| L | N | Ra | Vc | W |
| Lomalo clay | Shallow salty phase | Salty phase | Light colored phase | Flat phase |
| Lo | Ns | N | V | W |
| Lomalo and Nueces soils (Undifferentiated) | Prairie phase | Tiempo clay | Salty phase | Eroded phase |
| Ln | Np | Tc | V | D |
| Point Isabel fine sandy loam | Raymondville fine sandy loam | Victoria fine sandy clay loam | Victoria clay | Coastal beach |
| Pf | Rf | Vf | V | Cb |
| Nf | Rf | Vf | V | |
| High phase | Salty phase | Salty phase | | |

Alkali
1.14
1.15
Location of borings and result of field tests.
The upper figure shows the percentage concentration in the surface foot.
The lower figure shows the average concentration in a depth of five feet.